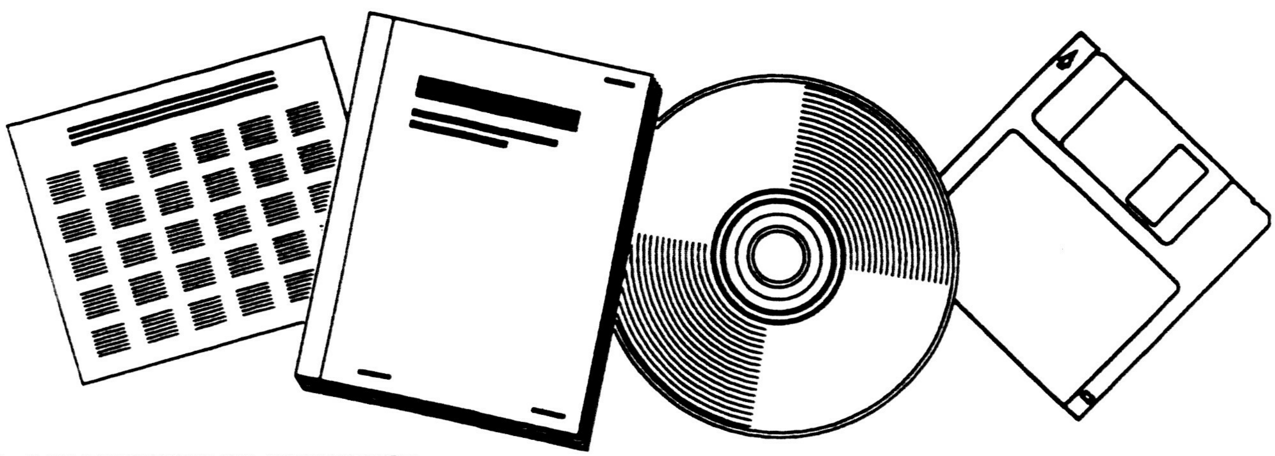
SATURN ILLUSTRATED CHRONOLOGY

MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, AL

AUG 1968



U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

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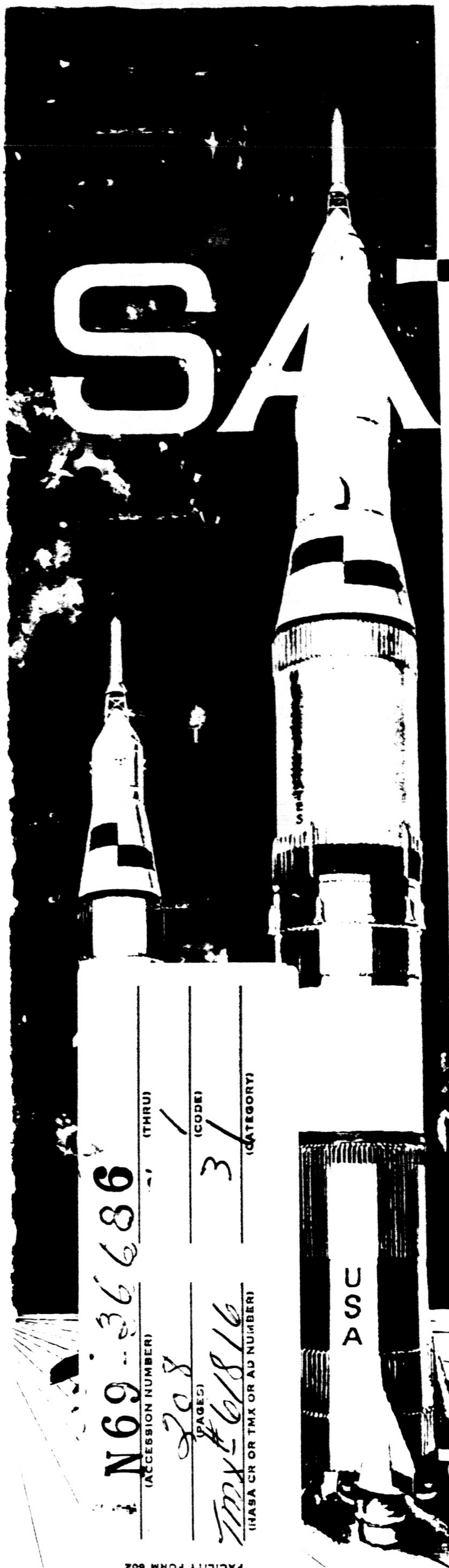
MHR-5

AUGUST 1, 1968

MARSHALL SPACE FLIGHT CENTER

HUNTSVILLE, ALABAMA



SATURN

HISTORICAL OFFICE
MANAGEMENT SERVICES OFFICE

SATURN ILLUSTRATED CHRONOLOGY

SATURN'S FIRST TEN YEARS

APRIL 1957 through APRIL 1967

Revised and updated : David S. Akens

RQ7-55841

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MSFC - Form 774 (Rev. May 1966)

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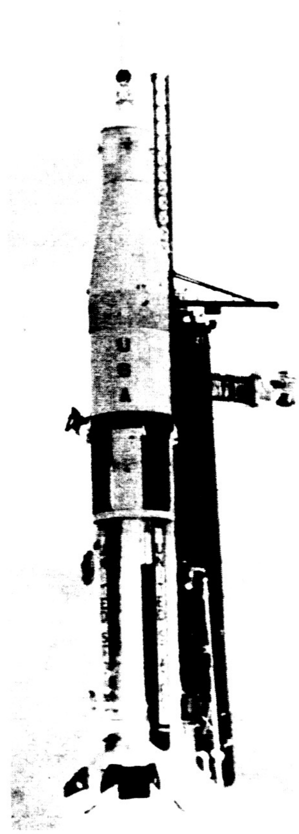
In April 1957 the scientific organization directed by Dr. Wernher von Braun began studies which led to Saturn, America's first rocket developed for space investigation. The team at Redstone Arsenal, Alabama, hoped to design launch vehicles that could carry 20,000- to 40,000-pound payloads for orbital missions or 6000- to 12,000-pound payloads for escape missions. High-thrust booster stages were essential.

In December 1957 the von Braun group, then working with the Army Ballistic Missile Agency (ABMA), proposed a program to the Department of Defense (DOD).[1] At that time the United States was considering an integrated missile and space vehicle development program. Creation of a booster with 1,500,000 pounds of thrust was the aim of the proposed program.

To secure this much power ABMA first considered clustering four 380,000-pound thrust Rocketdyne E-1 engines.



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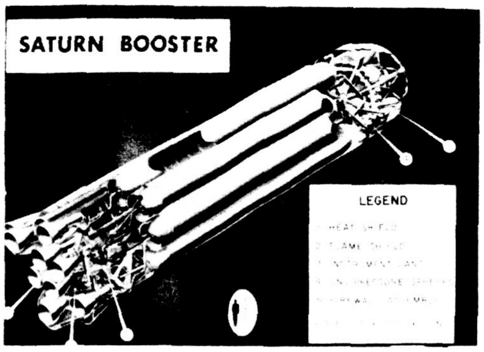

1. Proposed configuration of a clustered booster.

This initial concept was discarded because of the time required to complete development of this type engine. However, ABMA continued studies to determine if engines already developed could be used.

On August 15, 1958, the Advanced Research Projects Agency (ARPA) formally initiated what was

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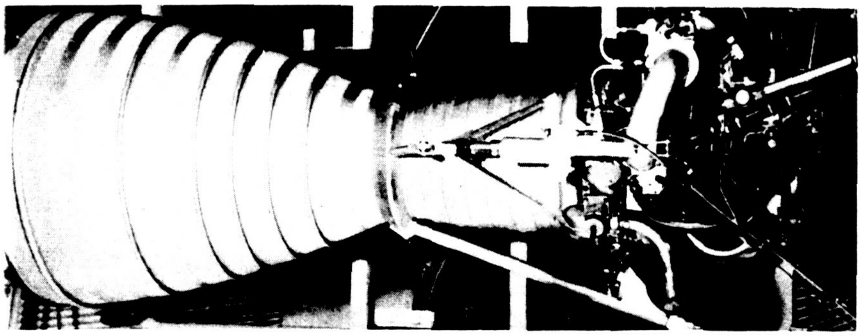

2. Thor-Jupiter engine
3. Booster tooling

to become the Saturn project. The agency, a separately organized research and development arm of the Department of Defense, authorized ABMA to conduct a research and development program at Redstone Arsenal for a 1,500,000-pound thrust vehicle booster. A number of available rocket engines would be clustered. This design would be tested by a full-scale static firing by the end of 1959.[2]

The liquid oxygen (LOX) and fuel tanks developed for the Redstone and Jupiter missiles could be

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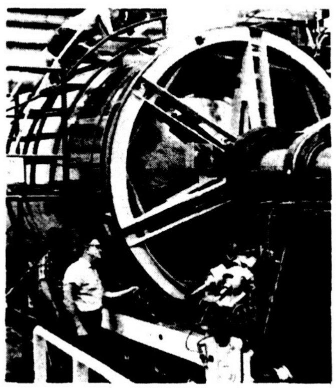

modified for use in the proposed booster. An existing engine, the S-3D, used on both the Thor and Jupiter missiles, could be modified to produce an increased thrust of 188,000 pounds. Numerous tools and fixtures developed for the Redstone and Jupiter program could also be used with comparatively little modification. Thus it was possible to begin booster development with hardware of proven reliability. Time for design and development of some important booster components and tooling could be significantly shortened and cost reduced.

As an immediate step a contract was awarded Rocketdyne Division of North American Aviation on September 11, 1958, to uprate S-3D, the Thor-Jupiter engine. After redesign, simplification, and modification, the engine would be the H-1.

In October 1958 ARPA expanded its program objectives. A multistage carrier vehicle capable of performing advanced space missions would be built. The vehicle was tentatively identified as Juno V. ARPA requested Redstone personnel to study a complete vehicle system so that upper-stage selection and development could begin, and initiated a study of Atlantic Missile Range (AMR) launch facilities which could accommodate the launch vehicle.[3] Later, on December 11, 1958, ARPA authorized the Army Ordnance Missile Command (AOMC) to begin design, modification, and construction of a captive static test tower and

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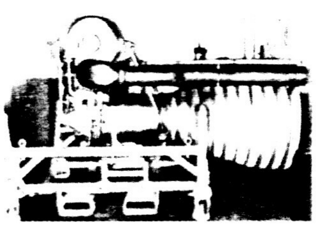

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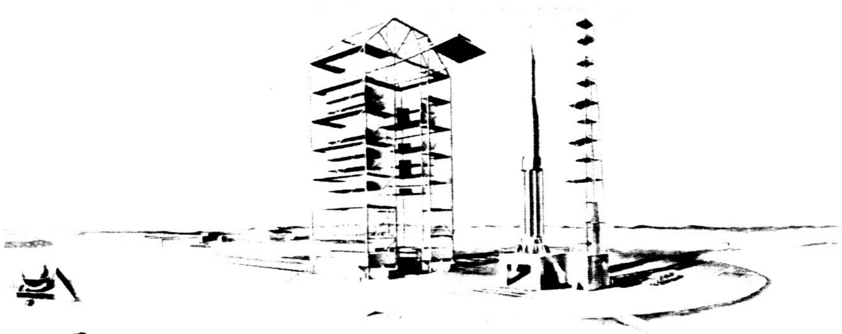

4. Early H-1 Engine
5. Preliminary concept of Launch Complex 34, Cape Canaveral

facilities for use in the booster development program. AOMC was also to determine the design requirements for necessary launch facilities.[4]

While the booster-vehicle program was being formulated and expanded, development work on the H-1 engine continued. The first full-power H-1 engine firing occurred in December 1958 at the Rocketdyne facility in Canoga Park, California.

Concurrently with development of the H-1 engine, studies were conducted pertaining to the feasibility of a larger single-chamber rocket engine. On January 9, 1959, Rocketdyne agreed by contract to design, develop, and test such an engine, designated as the F-1. This engine, burning LOX and RP-1, a kerosene-type fuel, would generate a very high thrust, approximately 1,500,000 pounds.

Construction of the ABMA static test stand for large boosters began January 10, 1959. Meanwhile, Army representatives of the ARPA board visited AMR to discuss selection of a site for large vehicle launch facilities at Cape Canaveral, Florida. By February 1959, a contract had been awarded for construction of the blockhouse at the site (Launch Complex 34). A design contract was also awarded for a movable structure which would be used to assemble and service the vehicle on the launch pedestal.

On February 3 an ARPA memorandum officially renamed the large launch vehicle project Saturn. ARPA representatives presented the proposed National Vehicle Program to the President and the National Aeronautics and Space Council on March 2, 1959. Included were the proposed Saturn B and C vehicle systems.[5]

On March 13 ABMA submitted to ARPA the results of the Saturn System Study. This study indicated that either an Atlas or a Titan could be used as the second stage of the proposed vehicle.[6] During May ARPA decided that modified Titan hardware

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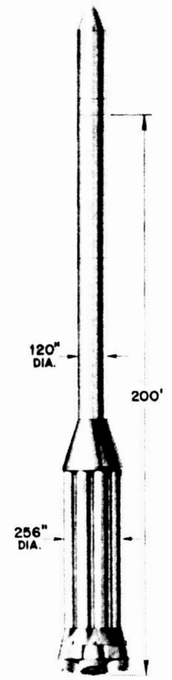

6. *Saturn B*
7. *Saturn C*

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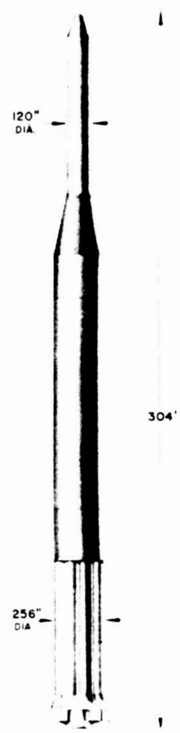

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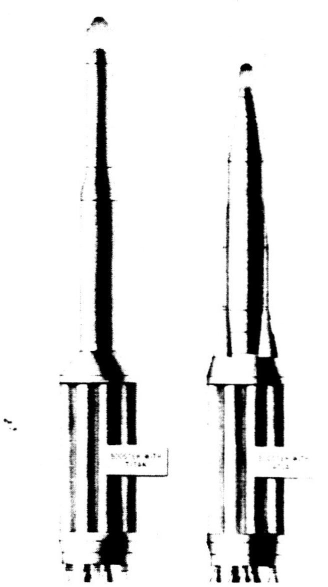

8. *Vehicles using Titan and Atlas stages*
9. *Atlas Centaur vehicle (Centaur second stage) showing a. Atlas stage, b. second stage, c. payload, d. electronic and guidance package, e. liquid hydrogen tank, f. LOX tank, and h. RP-1 tank*

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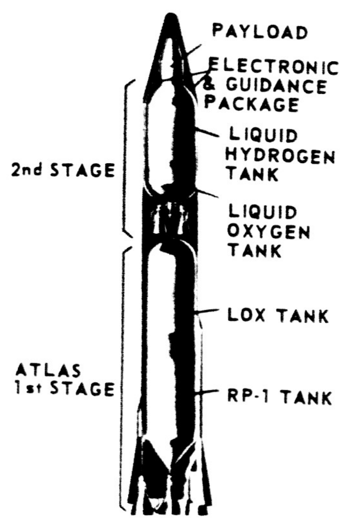

could be used for the second stage and that the third stage could use a slightly modified Centaur vehicle.

By April 28 the first production H-1 engine (H-1001) had been delivered on schedule to ABMA. ABMA's first firing test of this engine, later used in the first test booster, was performed successfully on May 26, 1959.[7]

On July 5, 1959, construction of the Saturn blockhouse for Launch Complex 34 began at Cape Canaveral. On July 27 when the last Jupiter airframe was completed, Redstone Arsenal shops began retooling to support the Saturn project.

Late in July the Director of Defense Research and Engineering notified the Air Force and ARPA to consider common development of the Saturn second stage and the booster for the proposed Dyna Soar; requirements for these stages appeared to be similar. Until review of this, neither agency was to make a firm commitment for the redesign of existing boosters or development of new ones.

ARPA then ordered cessation of the AOMC in-house and contractor work relating to the Titan second stage. An exception was made of some preliminary work not directly connected with the stage diameter.[8]

Work continued on the Saturn booster stage. While studies of the proposed Saturn-Dyna Soar combination were in progress, ARPA, on August 1, authorized ABMA to proceed toward captive firing the Saturn booster early in 1960.

In September representatives of AOMC, NASA, and the Air Force presented Saturn, Nova, and Titan C systems to the Booster Evaluation Committee of the Office of the Secretary of Defense. On the basis of these presentations ARPA chose Saturn. ARPA then requested that Redstone scientists determine the Saturn configurations which could best carry NASA payloads.

During October 1959 consideration of Saturn vehicle configurations continued. On October 29 and 30 ABMA presented a second Saturn System Study to ARPA and National Aeronautics and Space Administration (NASA), proposing various upper-stage configurations which offered increased payload capability and growth potential. In December 1959, after evaluation of previous presentations, NASA and ARPA requested that AOMC prepare an engineering study for a three-stage Saturn configuration.

Because of its large size and weight, the Saturn booster could not be transported by air or land. Water transportation appeared most feasible, and ARPA, on October 23, 1959, authorized AOMC to proceed with engineering work for dock facilities. These would be located on the Tennessee River at the southern boundary of Redstone Arsenal. In December AOMC was further authorized to construct the facilities and to build a barge to transport the booster to Cape Canaveral.

On November 18 NASA assumed technical direction of the Saturn project pending its formal transfer from ARPA. Administrative direction was retained by ARPA until March 16, 1960, when transfer of both administrative and technical direction would become effective.

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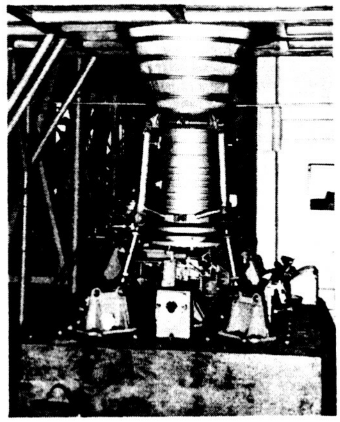

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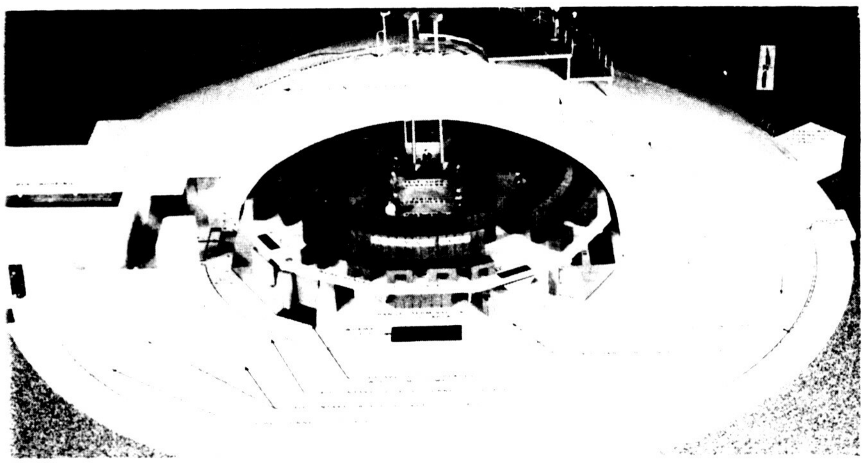

10, H-1 engine in alignment fixture
11, Model of blockhouse at Launch Complex 34

On December 15 the Saturn Vehicle Evaluation Committee (the Silverstein Committee) reached a decision on Saturn upper-stage configurations. This committee, composed of representatives from NASA, ARPA, DOD, and the Air Force, recommended a long-range development program for a Saturn vehicle with upper-stage engines burning liquid hydrogen and liquid oxygen. The initial vehicle, identified as C-1, was to be a stepping stone to a larger vehicle, the C-2. A building-block concept was proposed that would yield a variety of Saturn configurations, each using previously proven developments as far as possible. These recommendations were accepted by the NASA Administrator. On December 31, 1959, a ten-vehicle program was established.[9]

The C-1 vehicle configuration included the S-I, the S-IV, and the S-V stages. The S-I stage would have eight H-1 engines. Fueled by LOX/RP-1, the engines clustered were expected to produce a

12. C-1 and earlier vehicles: a. Redstone, b. Jupiter-C, c. Mercury Redstone, d. Jupiter, e. Juno II, and f. Saturn C-1
13. Proposed C-2

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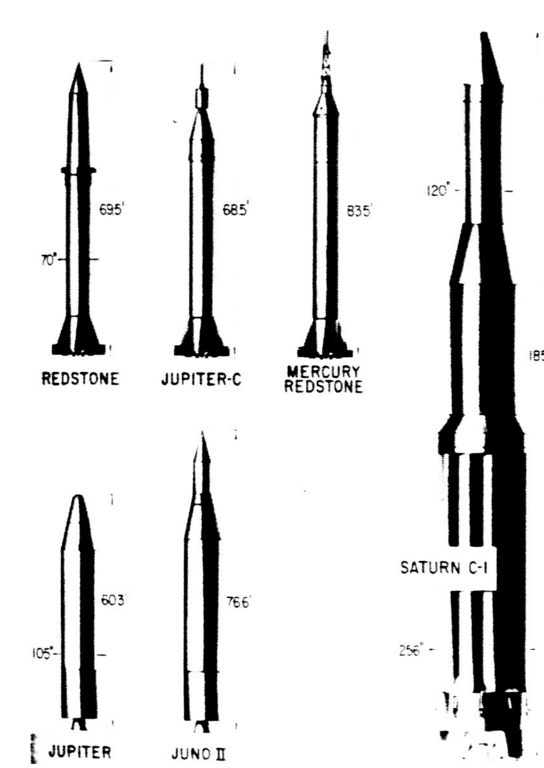

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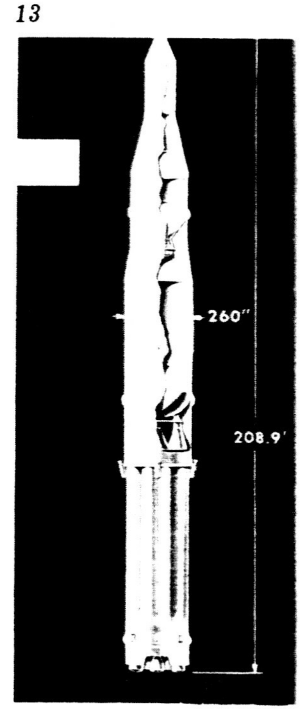

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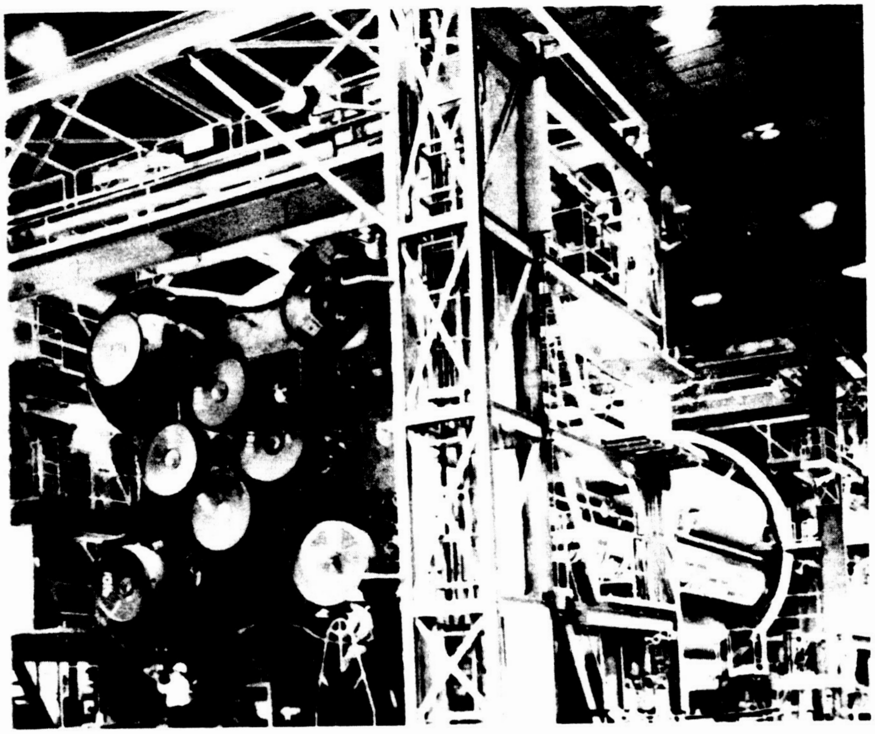

14. Booster stage (S-I)
15. Second stage (S-IV)

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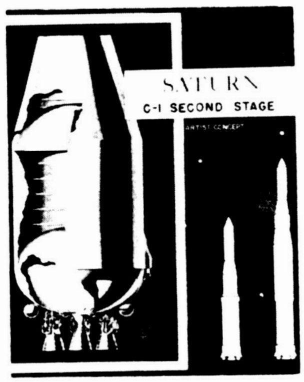

total of 1,500,000 pounds of thrust. The S-IV stage was conceived of as a four-engine liquid oxygen-liquid hydrogen fueled unit capable of producing a total of 80,000 pounds of thrust. The S-V stage would use two of the same engines as the S-IV stage and this stage would provide an additional 40,000 pounds of thrust.

The Saturn project was approved on January 18, 1960, as a program of the highest national priority (DX rating).

To develop the second stage of Saturn C-1, NASA sought a contractor. A bidder's conference concerning this S-IV stage was held at Huntsville, January 26 and 27, 1960. By February 29 twelve companies had submitted contract proposals.

Redstone Arsenal scientists started to work on the first stage. By 1960 the formal test program to prove out the clustered booster concept was

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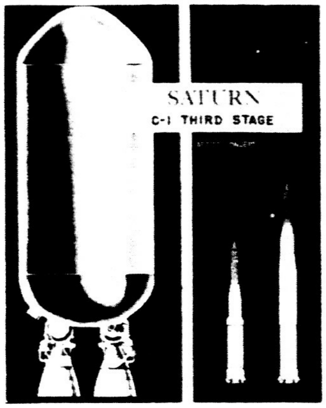

16. Third stage (S-V)
17. Moving Saturn test booster from assembly to test
18. Booster in test stand

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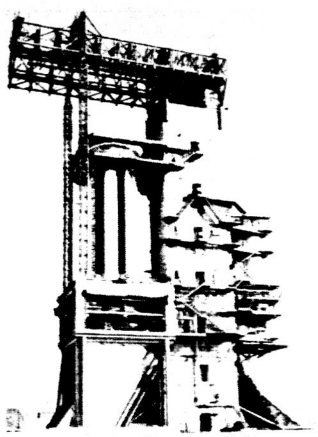

well under way. A mockup of the Saturn booster was installed in the ABMA test stand on January 4, 1960, to check mating of the booster and stand and to test servicing methods. This mockup was removed from the test stand and the complete test booster, SA-T, was installed in its place during February 1960.

During March the executive order transferring the Saturn program to NASA became effective.[10] Later in the month two of Saturn's eight first-stage engines passed an initial static firing test of

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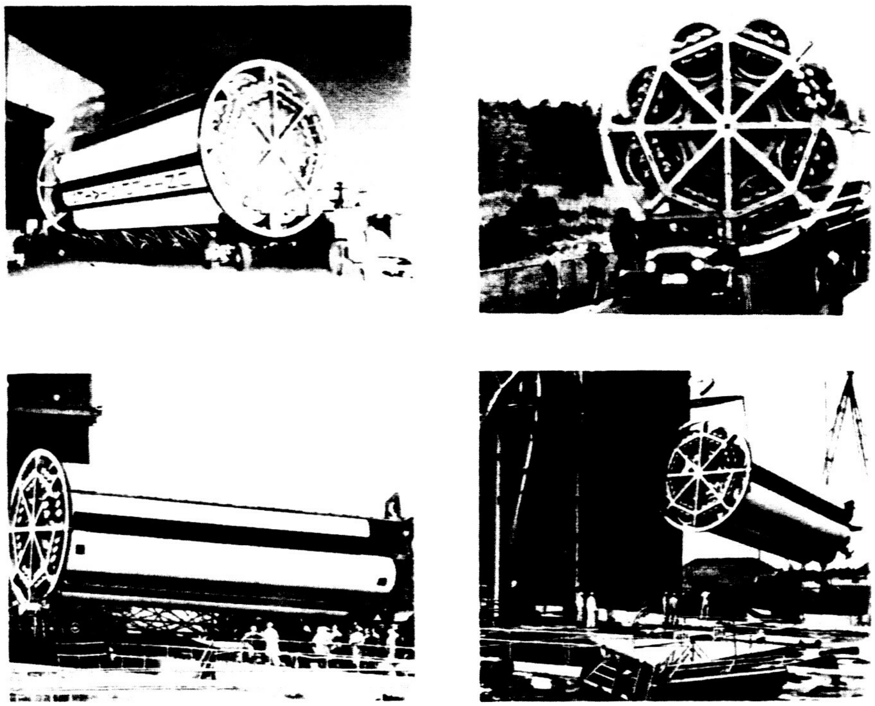

approximately eight seconds' duration. This test was identified as number SAT-01, the first live firing of the Saturn test booster (SA-T). It occurred on March 28.[11] In a second test (SAT-02), on April 6, four engines were successfully static fired for seven seconds. All eight engines of the test booster were successfully fired on April 29 in an eight-second test.[12]

On May 17 a second eight-engine static firing of 24 seconds' duration generated a thrust of 1.3 million pounds. The third successful eight-engine firing lasted 35 seconds.[13]

Meanwhile, NASA reviewed the S-IV proposals received in February. On April 26 NASA awarded Douglas Aircraft Company a contract to develop and build the second stage.

During May NASA announced that Rocketdyne had been selected to develop the high-thrust J-2 engine. This engine, of the type defined by the Silverstein Committee in December 1959, would burn liquid hydrogen-liquid oxygen. It would be used in an advanced Saturn vehicle.

The first ten Saturn flight vehicles would be numbered from SA-1 to SA-10. SA-10 would be the prototype of the operational Saturn.

On May 26, 1960, assembly of the booster stage for the first Saturn flight vehicle began in Huntsville.

On July 1, 1960, the Saturn program was formally transferred to the George C. Marshall Space Flight Center (MSFC).[14] A second series of static tests had just been successfully completed on the first stage of Saturn C-1.

On July 26 NASA signed a supplemental agreement with Douglas Aircraft Company covering the second stage. Douglas would design, develop, and fabricate the four-engine S-IV stage.

Contracts were also let on August 10, 1960, with Pratt & Whitney to develop and produce LR-119 engines; the Government would furnish these engines to the contractors responsible for building the S-IV and S-V stages of the C-1 vehicle. The LR-119, an uprated LR-115 engine, was expected to generate 17,500 pounds of thrust.

On August 14, 1960, construction began on the

19. Booster static firing
20. Model of J-2 engine

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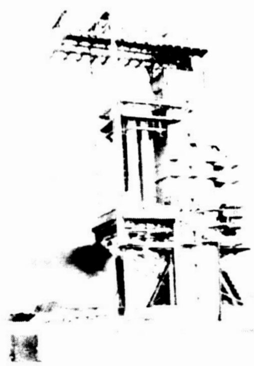

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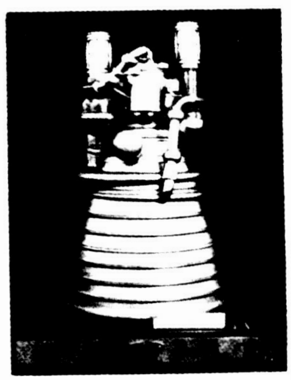

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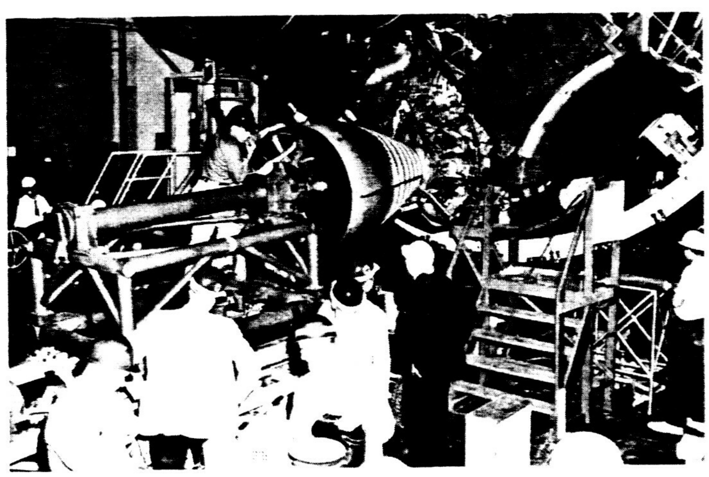

21. Assembly of main LOX tank for SA-1 booster
22. Assembly of tanks on SA-1 booster
23. Structural fabrication of SA-1 booster

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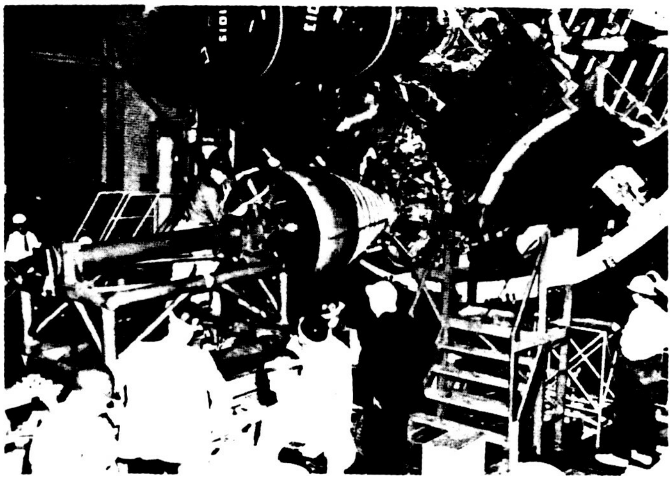

movable service structure for Launch Complex 34 at Cape Canaveral.

On August 15 the Air Force requested NASA assistance in planning the application of Saturn to Dyna Soar. After conferring with Air Force, MSFC agreed on October 6 to provide a preliminary study.

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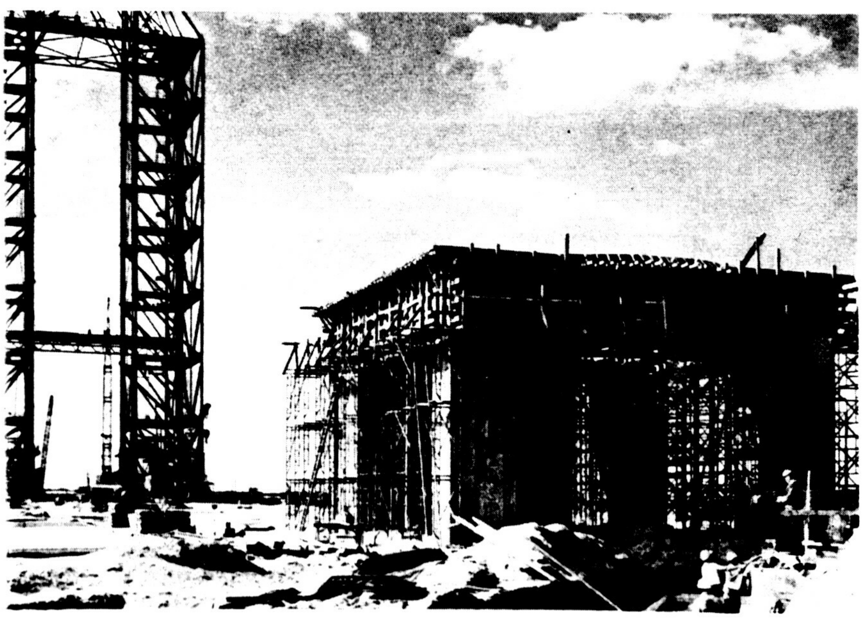

24. Installation of engines on SA-1 booster
25. Initial configuration of the S-IV stage
26. Construction of service tower and pedestal

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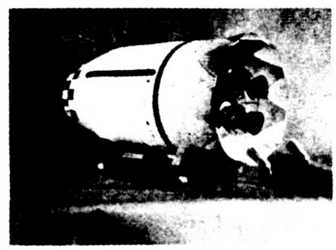

27. Unveiling bust of General George C. Marshall
28. Dr. von Braun and President Eisenhower
29. Mr. Glennan, President Eisenhower, and Dr. von Braun
30. Proposed Saturn C-1 Apollo Configuration

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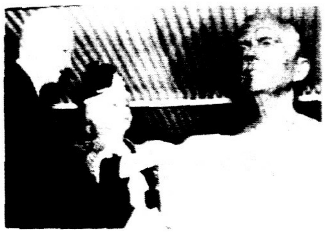

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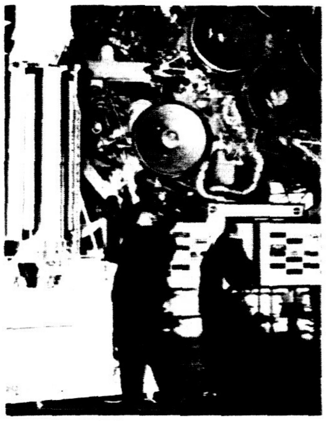

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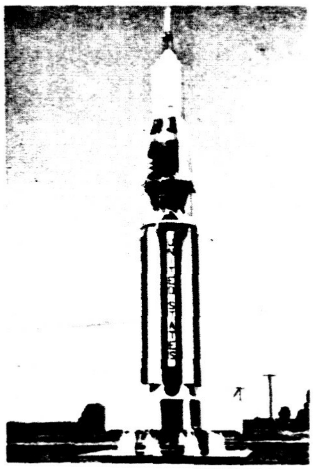

On September 8 the facilities of the National Aeronautics and Space Administration at Huntsville, Alabama, were dedicated and designated as the George C. Marshall Space Flight Center. President Eisenhower, Mrs. George C. Marshall, NASA Administrator T. Keith Glennan, and many other national, state, and local dignitaries participated in the ceremony.

On October 21 NASA awarded to Convair a study contract for a second upper stage, the S-V. On October 25 NASA selected Convair, General Electric, and Martin to conduct individual feasibility studies of an advanced manned spacecraft as part of Project Apollo.[15]

MSFC started a new series of static firing tests of the test booster (modified to the SA-1 flight configuration and designated SA-T1) on December 2, 1960. An eight-engine test lasting two seconds was first. The next week a test of two engines was conducted in a six-second firing. The series of booster tests was successfully concluded on December 20, 1960, by a 60-second firing of all eight engines. Fabrication of the tanks for the booster stage of the second Saturn flight vehicle (SA-2) was completed during December. Assembly of the booster began immediately.

In January Convair Astronautics submitted a proposal for an S-V upper stage for the Saturn vehicle; however, later in the month Dr. von Braun proposed that the C-1 vehicle be changed from a three-stage to a two-stage configuration in support of the Apollo program. NASA decided to delete requirements for the S-V stage on C-1 vehicles.

On January 16 the booster stage for the SA-1 flight vehicle was moved from assembly to checkout. During January also, wind tunnel testing of a model Saturn booster began at the Arnold Engineering Development Center, Tullahoma, Tennessee; the tests were designed to study base heating phenomena of the clustered stage.

Two additional studies began in January 1961. NASA awarded North American and Ryan Aeronautical Company contracts to investigate feasibility of recovering the S-I booster stage after the vehicle flight by using a Rogallo paraglider. A design contract was awarded for equipment which would be used at MSFC to check out the S-I stage automatically.

On January 25 a meeting was held at MSFC to study S-II stage requirements for the Saturn C-2 vehicle. S-II stage trajectory, performance, and structural analysis calculations were completed and made a part of the preliminary Saturn-Dyna Soar proposal.[16]

During January a dummy of the S-IV stage was completed at MSFC and moved to checkout. On January 31 MSFC static fired all eight engines of the SA-T1 test booster for 113 seconds.[17]

A dummy S-V stage, built for use on SA-1, was received from Convair on February 8 and mated to the dummy S-IV stage. The first horizontal assembly of the complete C-1 vehicle was accomplished during February. MSFC completed SA-T1 static tests on February 14. By February 27 Convair had provided MSFC with a second dummy S-V stage.[18] This stage would first be used during dynamic tests of a complete dummy vehicle; later the dummy S-V would be used on a flight vehicle.

Liquid hydrogen engine development problems led to studies early in March to determine the possibility of using the first-generation LR-115 type Centaur engine on the Saturn S-IV stage, rather than second-generation Centaur engine, the LR-119.

Meanwhile, the booster was removed from the test stand on March 2 and loaded aboard the Palaemon for river trials. Also on March 2, 1961, as a part of the booster recovery studies, tests began at Cape Canaveral to determine the feasibility of reusing H-1 engines after exposure to salt water.

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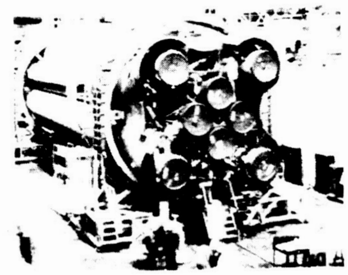

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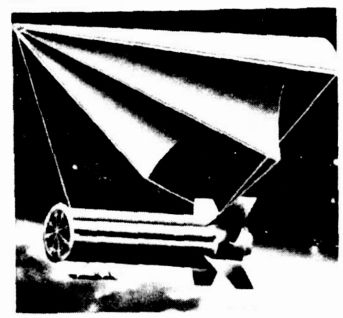

31. SA-1 Checkout
32. Saturn booster recovery
33. C-2 Second Stage concept

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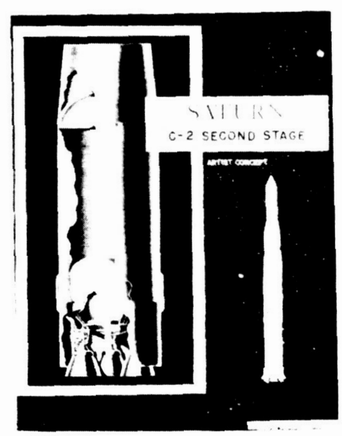

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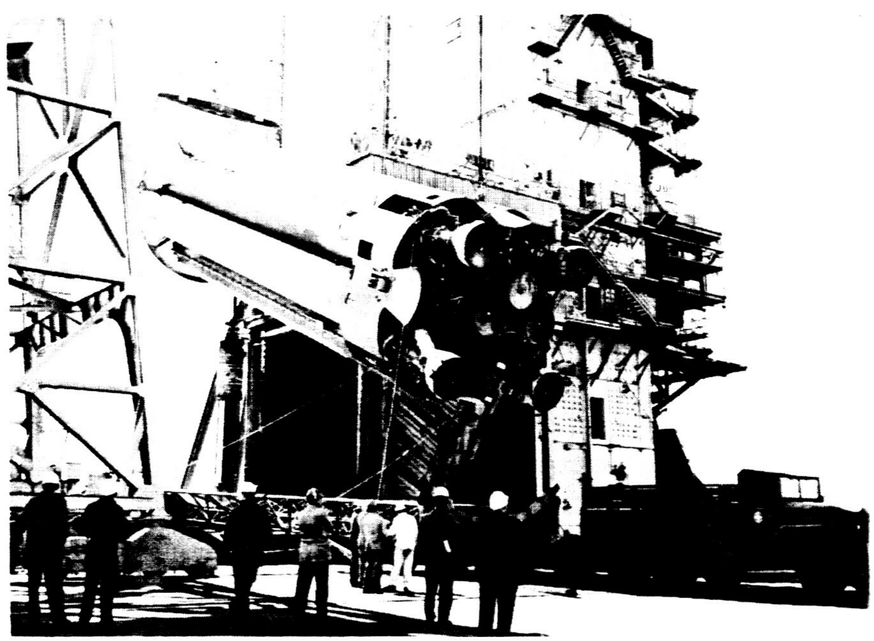

34. Movement of dummy S-IV stage to checkout

35. First horizontal mating of the Saturn vehicle

36. Removal of the booster from the static test stand

Construction work at Launch Complex 34 continued to progress satisfactorily, with the service structure, blockhouse, and gas facilities nearing completion.

On March 7 the SA-1 booster was moved to the MSFC static test stand for preflight checkout. On March 14 the Palaemon, carrying the SA-T1, left the MSFC dock on its first training trip. Following its return the test booster went to MSFC shops for modification to the SA-T2 configuration. Looking beyond the booster, MSFC began construction in March of a facility to be used in familiarizing personnel with the handling of liquid hydrogen. MSFC presented plans on March 23 to accelerate the C-2 program and recommended that a prime contractor be selected to develop the S-II stage. MSFC also recommended use of six LR-115 engines in the S-IV stage instead of four LR-119 engines. Pratt & Whitney would still be the supplying contractor. MSFC then proposed certain design changes in the S-I stage including an increase in propellant capacity, the addition of fins, and increased structural support for later versions of the booster.

On March 29, 1961, MSFC received NASA Headquarters approval for the six-engine configuration

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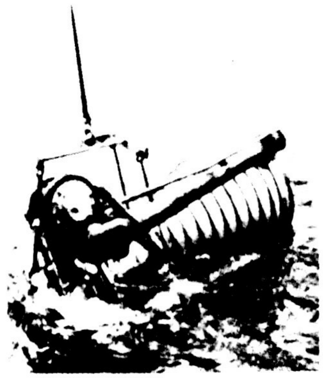

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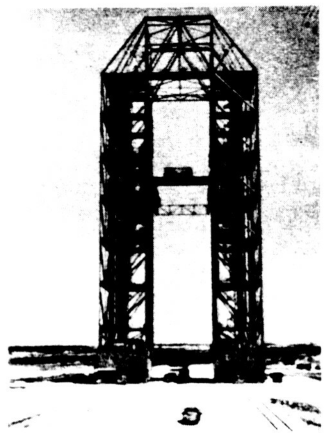

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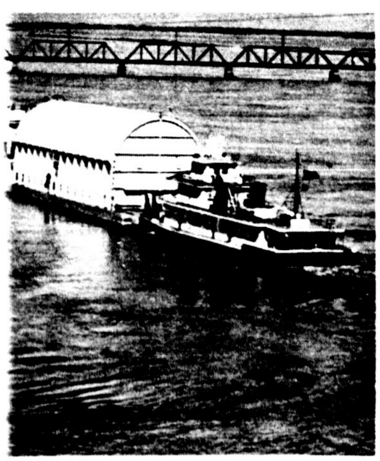

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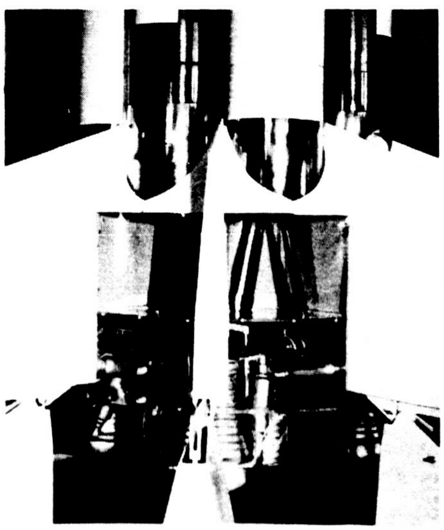

37. Salt water test of H-1 engine
38. Facilities construction at Launch Complex 34
39. The barge Palaemon
40. Redesigned tail of the Saturn booster

41

41. Six-engine configuration of the S-IV stage

42. Artist's concept of Apollo capsule

43. Air transport of S-IV stage

of the S-IV.[19] On March 31 NASA approved acceleration of the C-2 program and development of the C-2 vehicle for a three-stage escape mission. MSFC was authorized to begin a two-phase procurement of an S-II stage.[20]

During March further decisions were made concerning engines for the S-IV stage. MSFC decided to redirect effort from development of the LR-119 to the RL10-A-1, an engine that could be used in common by both the Centaur and the S-IV stage.

On April 10 NASA announced the Project Apollo objective of developing an orbiting laboratory for the study of effects of radiation and prolonged weightlessness, first with animals and later with

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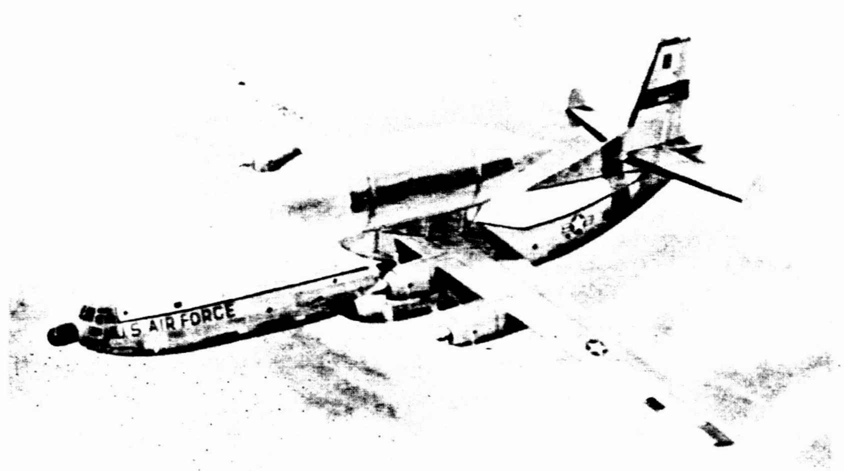

a three-man crew. During April Douglas reported that air transport for the S-IV stage was feasible. Douglas had been authorized in 1960 to study air transportation for S-IV stages. This would greatly reduce the time which would be required if the stages were moved by water from California to MSFC at Huntsville, and thence to Cape Canaveral, Florida. The use of gliders, blimps, and aircraft to carry the stages was also considered.

On April 17 the Palaemon began its first trial run to Cape Canaveral. The barge carried a water-ballasted tank simulating the size and weight of the S-I booster, plus a dummy S-V stage for the SA-1. The barge reached Cape Canaveral on April 30. After rehearsing movement of the booster along roads at the Cape, the simulator was reloaded aboard the Palaemon. The dummy S-V stage remained at the Cape. On May 3 the barge began its return trip, arriving at the Redstone Arsenal dock May 15.[21]

MSFC completed construction of the dynamic test tower on April 17, the same day that the Palaemon left for Florida. The dynamic tower permits checkout of the mechanical mating of the C-1 vehicle, and aids in determining the vehicle's natural bending characteristics and the effect of simulated flight vibrations.

MSFC held a Saturn S-II preproposal conference April 18; the first phase of S-II procurement was expected to begin during May. On April 21 Douglas reported to MSFC that the major problem in S-IV stage development was disposal of hydrogen gas generated during engine chilldown.

On April 29, 1961, the first flight qualification test (SA-01) of the SA-1 booster was successfully accomplished in an eight-engine, 30-second test. A second static firing of the SA-1 booster, May 5, 1961, was terminated prematurely because of a problem which caused a shutdown signal through the fire detection system.[22]

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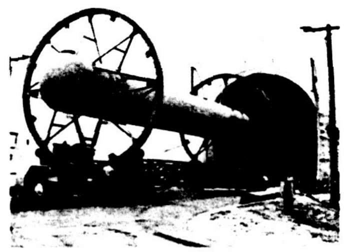

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44. Booster simulator being loaded aboard Palaemon
45. Unloading simulator at the Cape
46. Route of the Palaemon to Cape Canaveral
47. Installing dummy S-I on Dynamic Test Tower

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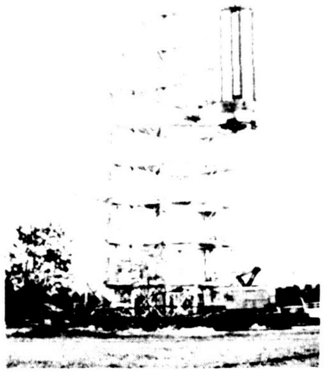

A third eight-engine static firing test of the SA-1 booster, performed May 11, lasted 111 seconds and was satisfactory. Meanwhile, assembly of the SA-2 flight vehicle continued, and fabrication of the LOX and fuel tanks for the SA-3 vehicle was begun.[23]

In May 1961 NASA Headquarters accepted MSFC's March proposal to incorporate design changes into the S-I stage of the C-1 vehicle. The changes would permit the C-1 to be used as a two- or three-stage vehicle possessing satisfactory safety requirements for the two-stage manned mission. This change eliminated the immediate need for an S-V stage with the C-1 except for possible special missions. Also during May 1961 MSFC began re-examination of the capabilities of the Saturn C-2 configuration to support lunar circumnavigation missions. Results of this examination indicated that a Saturn vehicle of even greater performance would be desirable.

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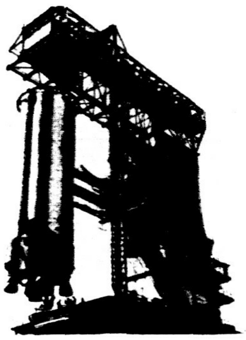

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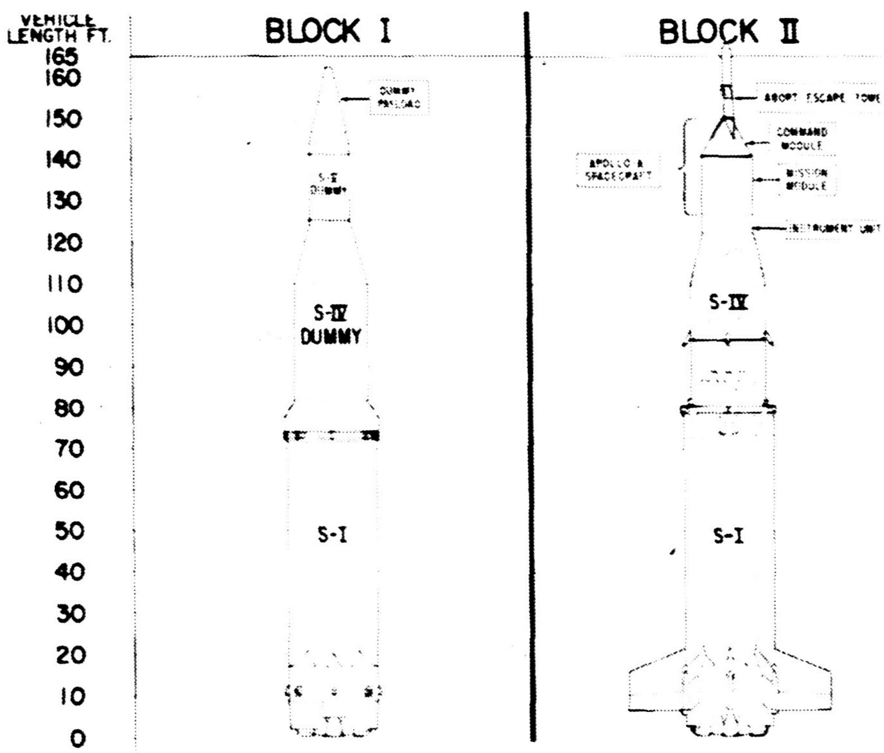

48. Positioning flight booster in test stand
49. Configurations of Saturn flight vehicles
50. Separation of upper stages from booster

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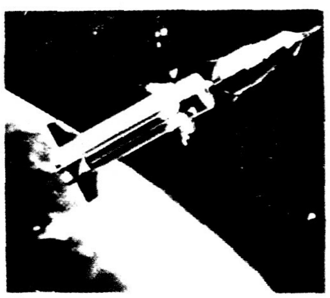

On May 18 the first phase of S-II procurement began when MSFC requested industry to prepare capability proposals for the design and development of the stage. Also during May Pratt & Whitney shipped a mockup of the RL10-A-3 engine to Douglas and Convair for checks to assure that the engine was physically compatible with both the S-IV stage and the Centaur vehicle. Among other activities in May the Martin Company was awarded a contract to study launch vehicle systems which could be used in lunar exploration beyond the initial Project Apollo flights. These studies included transportation systems for a lunar landing and immediate return for three men, a thirty-day stay on the moon for three men, and a permanent moon base to accommodate 10 to 12 men.

MSFC tested the S-IV dummy stage for the SA-1 flight vehicle May 20-25, 1961. After successful testing the Center began to ready the stage for shipment to Cape Canaveral.

During June construction of the liquid hydrogen test site neared completion at Douglas Aircraft's Sacramento Test Facility (SACTO). Utilizing LOX facilities existing from earlier programs, the site includes two 90,000-gallon liquid hydrogen storage tanks and test stands capable of testing S-IV hardware under a variety of conditions.

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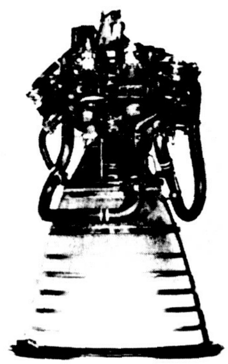

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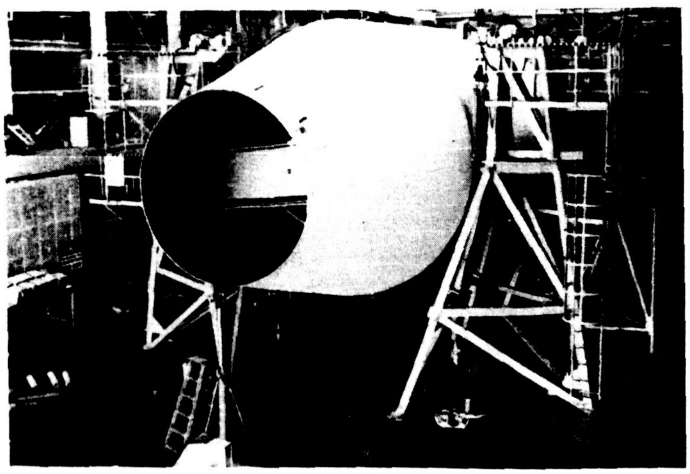

51. Model of the RL10-A-3 engine
52. Testing of dummy S-IV stage

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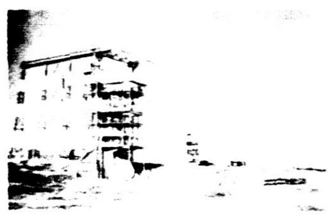

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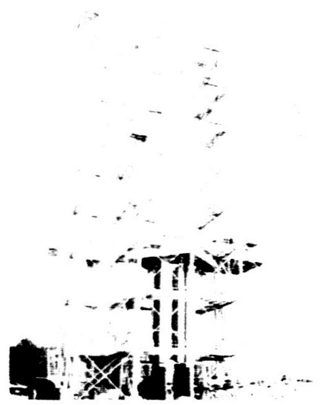

53. Sacramento test facility
54. Dummy Saturn vehicle in dynamic test stand
55. Tail Area mockup
56. Forward interstage mock-up

Engine gimbal tests performed at MSFC during April and May had indicated the advisability of increasing the stiffness of the engine control support structure in the booster. To investigate this matter further, the control engine support structure of the S-I stage of the dynamic test vehicle was modified and a series of single-engine gimbal tests begun on May 29, 1961. As test results were of marginal satisfaction, a new type of actuator servo valve was installed. Further test results were satisfactory. The dummy booster was moved to the dynamic test stand early in June and, for the first time, vertically mated with dummy S-IV and S-V stages. The assembled vehicle was then readied for dynamic testing. [24]

During May and June 1961 Douglas Aircraft had continued fabrication of full-scale mockups of S-IV stage sections. These mockups are used to check the mating of different sections of the stage and to determine equipment locations.

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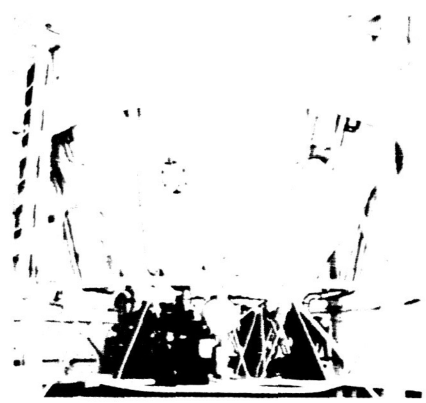

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On June 2 a lock collapsed at the Wheeler Dam on the Tennessee River. All movement of river traffic was halted. Because the Palaemon was trapped in the upper river, MSFC decided to transport the booster in it overland to a point below the dam. There the stage would be reloaded on barge to continue the trip to Cape Canaveral. To support this plan MSFC obtained a Navy barge which had been mothballed at Pensacola, Florida.

Necessary modifications began so that the new barge, renamed the Compromise, could carry the S-I and dummy S-IV stages and dummy payload.

On June 5, 1961, Launch Complex 34 at Cape Canaveral was dedicated in a brief ceremony and turned over to NASA.[25] In Huntsville final acceptance testing of the S-I stage for the first flight booster began on June 12, 1961. The first operation accomplished was the mechanical mating of the S-IV dummy stage. Design work for later Saturn vehicles also continued at MSFC. On June 15, 1961, a mockup of the new instrument unit portion of the vehicle was completed; this unit, containing guidance and instrumentation, would fly above the upper stages of the last five Saturn C-1 vehicles.

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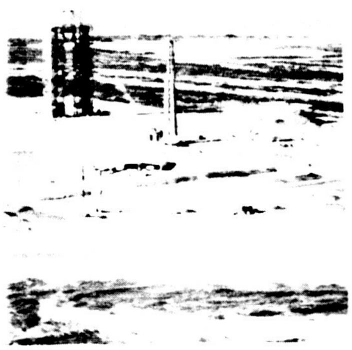

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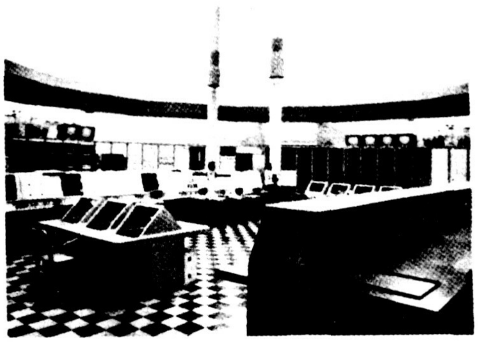

On June 21 Phase II procurement of the S-II stage began. Four companies were invited to attend the Phase II meeting at MSFC and submit proposals.

After a meeting held in June with Douglas, MSFC directed that the S-IV stage be redesigned to incorporate chilldown venting through which accumulated hydrogen gas could be disposed.

Dr. von Braun announced on June 23 that further engineering design work on the C-2 configuration would be discontinued; effort would instead be redirected toward clarification of the Saturn C-3 and Nova concepts. Capabilities of the proposed C-3

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57. The barge Compromise
58. Launch Complex 34
59. Launch Complex 34, blockhouse interior
60. Instrument unit mockup

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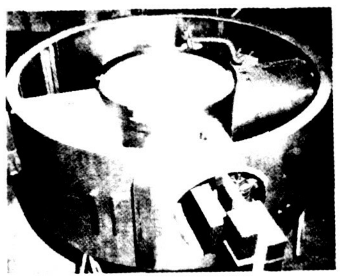
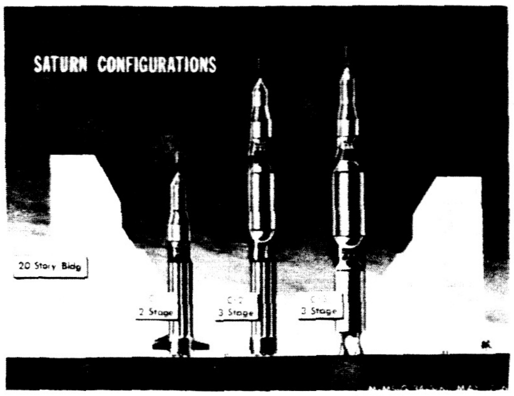


61. Comparison of Saturn
62. Possible Nova Configurations
63. Proposed C-3/Apollo configuration
64. Installation of SA-T2 on static test stand

61



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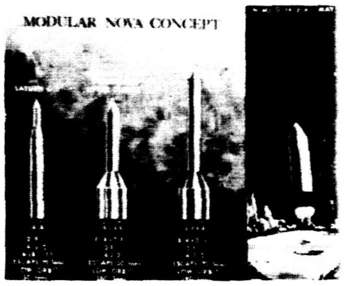

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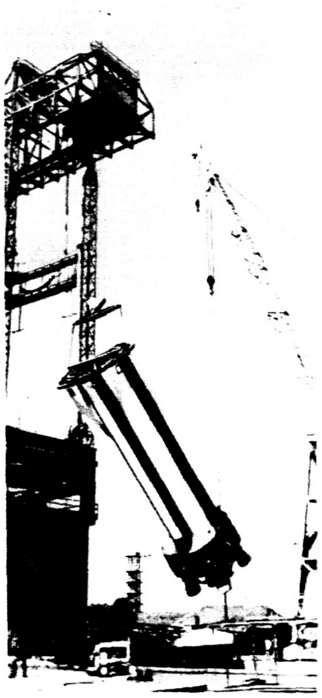

configuration in supporting the Apollo mission would be determined.

On June 27 the first static test of the SA-T2 booster (the SA-T1 booster modified to the configuration of the SA-2 booster stage) was successfully accomplished at MSFC. This was an eight-engine, 30-second test to confirm effectiveness of the new actuator servo valve and the stiffening of the control engine support structure.[26]

During the last week in June a contract was awarded to Chrysler Corporation for performance of qualification and reliability testing on various engine, hydraulic, mechanical, and structural components of the Saturn booster. Another contract was awarded in the same month for preliminary design of a facility to static test the J-2 engine.

To commemorate the first anniversary of Marshall Space Flight Center, an open house was held at the Center on July 1, 1961. Attending were such national figures as the NASA Administrator, James Webb; the Director of NASA Launch Vehicle Programs, Major General Don Ostrander; and numerous other national, state, and local dignitaries.

A few days later dynamic testing of SA-D1 began for the purpose of investigating the bending modes of the vehicle and also to continue studies into tank resonances initiated by Langley Research Center

during June. While dynamic testing proceeded at MSFC, Rocketdyne in California began static firing tests of a complete F-1 engine. The engine would build up to 1.5 million pounds of thrust when perfected.

Early in July MSFC awarded a contract to Minneapolis-Honeywell for necessary engineering and manufacturing services to adapt the Centaur guidance set to Saturn requirements. Also in July, MSFC awarded a six-month contract to the Boeing Company to study the feasibility of creating huge vehicles by joining solid-propellant "superboosters" with liquid-propellant upper stages.

During July MSFC successfully completed the second and third static firings of the SA-T2 test booster.[27] These tests evaluated modifications to reduce engine structure vibration, evaluated flame curtain materials, and checked out a LOX depletion system similar to that used on SA-1. During

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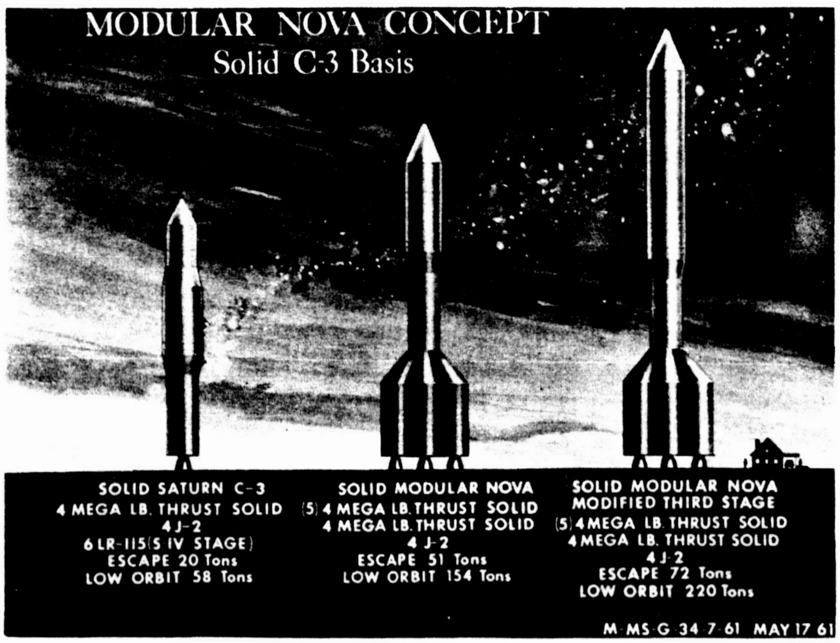

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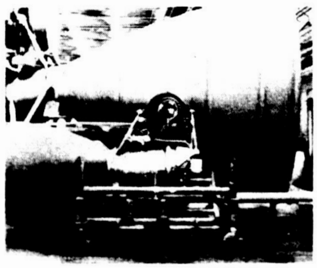

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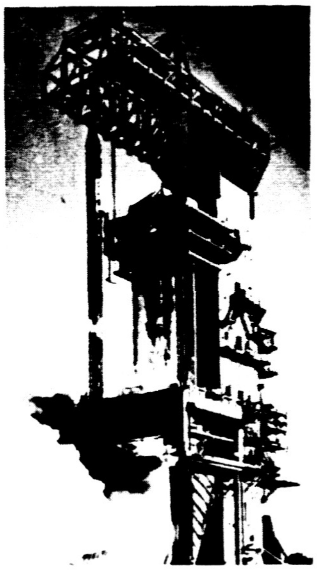

65. Dr. von Braun, James E. Webb, and Maj. Gen. Ostrander
66. H-1 and F-1 engine comparison (H-1 in foreground)
67. Static firing of F-1 engine
68. Proposed solid propellant boosters for large space vehicles
69. Static firing of SA-T2
70. Concept of new static test facility, MSFC
71. Artist's concept of Apollo separation from second stage

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the third test MSFC simulated for the first time the inflight engine cutoff sequence, that is, shutdown of the inboard engines six seconds before shutdown of the outboard engines.

MSFC awarded a contract to the Space Technology Laboratories, Inc., Los Angeles, California, during July, to investigate the relative merits and potential problems of assembling the giant Saturn boosters in horizontal and vertical positions. Other contracts awarded by the Center in July included qualification and reliability testing of Saturn ground support equipment, subsystems, and components, construction of a special assembly building at Cape Canaveral, and site development for the Center's new static test facility in Huntsville.

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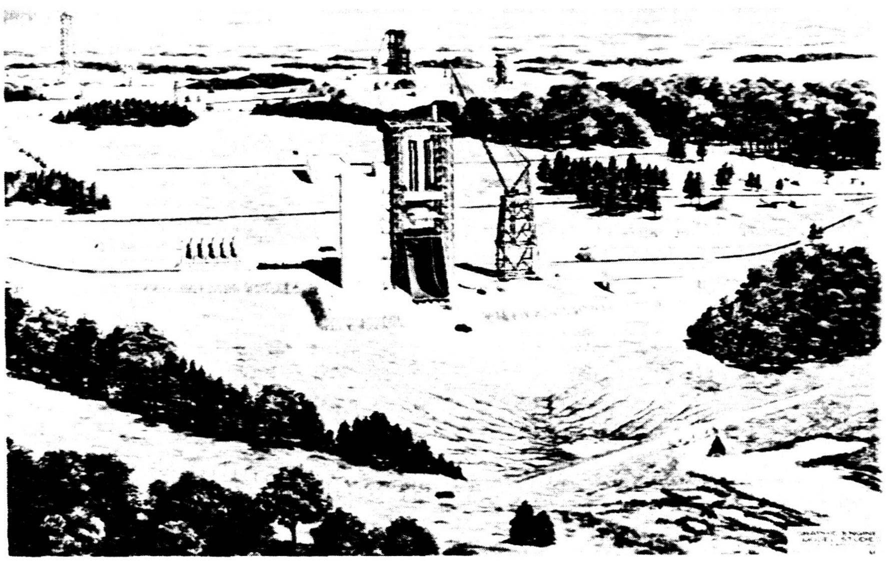

Also in July NASA's Space Task Group invited 12 companies to submit proposals for the manned lunar Apollo spacecraft. Meanwhile, the Center contemplated a nuclear-powered Saturn upper stage and awarded contracts for a six-month RIFT (reactor-in-flight test) design analysis to General Dynamics/Astronautics, Douglas Aircraft Company, Lockheed Aircraft Corporation, and the Martin Company.

Assembly of the booster stage for the SA-3 vehicle began on July 31, 1961.[28] The following day the SA-2 booster was transferred from the assembly area to checkout. On August 3 a planned 114-second static test of the SA-T2 booster was terminated after 1.2 seconds when instrumentation indicated an unacceptably high temperature of the LOX pump inlet on engine No. 1. The test was rescheduled for the following week. On August 7 the SA-T2 booster was successfully fired in a 124-second test.

Checkout of the SA-1 flight booster, started in June, was completed early in August.[29] The booster stage, the dummy S-IV stage, and the dummy payload body were shielded with protective covers and loaded on their respective transporters. The stages and payload body were then moved from the MSFC shops to the docking facilities on the Tennessee River and loaded aboard the Palaemon. On August 5 the barge began the first leg of the trip to Cape Canaveral. At Wheeler Dam the units

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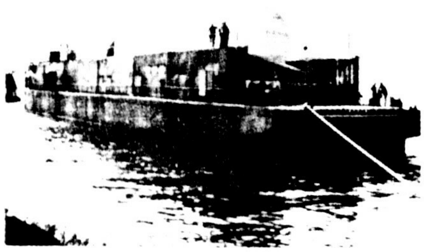

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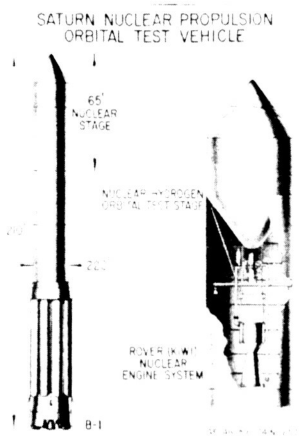

72. Concept of Saturn with nuclear powered stage

73. Booster movement to docking facility

74. Payload movement around Wheeler Dam

75. Booster movement around Wheeler Dam

76. S-I and S-IV stages aboard the Compromise

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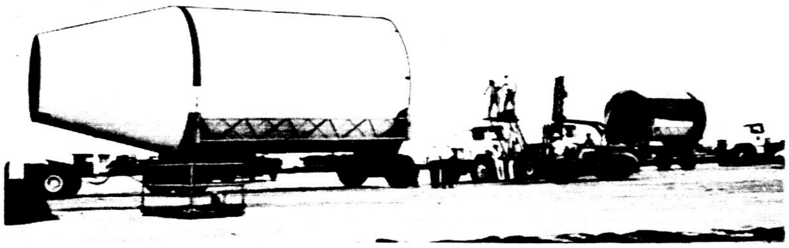

77. *Unloading Compromise in Florida*
78. *First Saturn booster erection at Cape Canaveral*
79. *S-IV erection at Cape Canaveral*
80. *Payload body erection into service structure*

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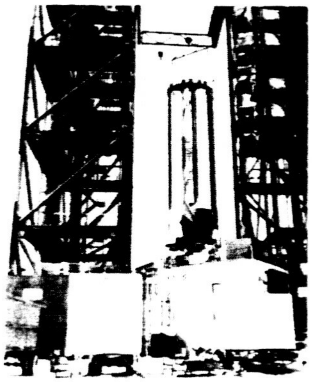

were unloaded, transported to a dock below the dam, and placed on the second barge, the Compromise, to continue the 2200-mile trip to Florida. On August 15 the Compromise arrived at the Cape and unloaded her cargo; MSFC began assembling the first flight vehicle on the launch pedestal.[30]

Early in August MSFC invited bids for the construction of a new Saturn launch complex (Launch Complex 37) at Cape Canaveral. Scheduled for completion in late 1962, the new complex would support the high launch rate planned for the Saturn vehicle.[31]

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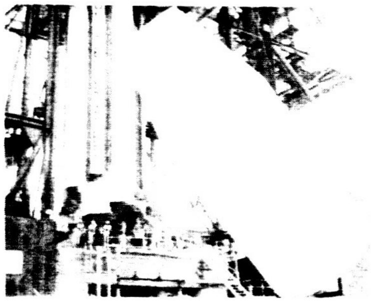

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An F-1 engine was fired on August 16 at Edwards Air Force Base; although the test was terminated after one and one-half seconds, the engine had built up one million pounds of thrust.

On August 24 NASA designated Cape Canaveral as the base for all manned lunar flights and other space missions requiring advanced launch vehicles. NASA would secure an 80, 000-acre tract of land, increasing its total area in the vicinity to

97,000 acres. The additional land was needed because of the tremendous vibration and noise expected with later launch vehicles.

On September 7 NASA selected the Government-owned Michoud Ordnance Plant near New Orleans as the site for industrial production of the S-I stage. The plant would be operated by industry under the technical direction of MSFC. MSFC continued preparations for a conference to secure estimates from industry on production of the S-I stage.[32]

On September 11 NASA selected North American Aviation to develop and build the S-II stage for an advanced Saturn launch vehicle. The stage will be used in both manned and unmanned missions.

Army Engineers awarded a contract on September 13 for the construction of Launch Complex 37 at Cape Canaveral. The complex would include a mobile steel tower, a blockhouse, and a cable tower on a 120-acre site at the north end of the Cape.

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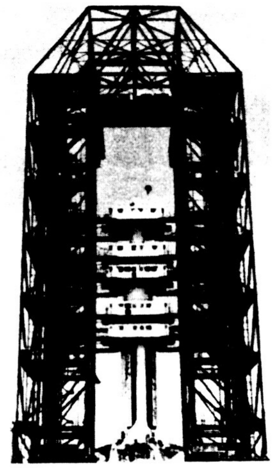

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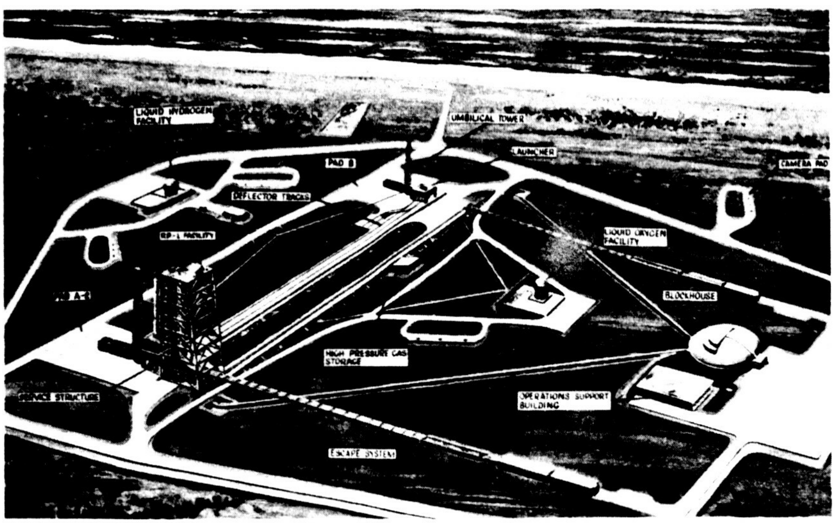

81. First Saturn assembled on Launch pedestal
82. Saturn launch complex 37
83. Artist's concept of launch pedestal for Launch Complex 37

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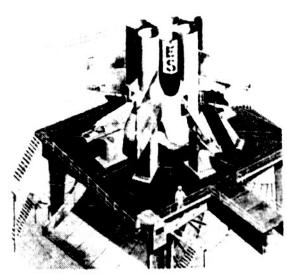

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84. *Michoud plant at New Orleans*
85. *Saturn SA-1 Flight vehicle on launch pedestal*

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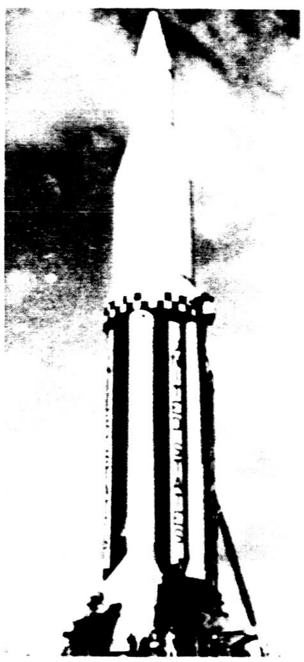

By September 15, 1961, the SA-1 vehicle was completely assembled on the launch pedestal at Launch Complex 34. The service structure was moved back, leaving the Saturn standing as it would at launch.

On September 26 a preproposal conference was held at New Orleans to secure bids for industrial production of the S-I stage. Four days later, on September 30, a ground-breaking ceremony was held to begin construction of the Marshall Center's Central Laboratory and Office Building.

Testing continued in September and October at the Marshall liquid hydrogen test facility, where problems in the handling and use of liquid hydrogen are studied. The SA-2 flight booster was installed in the MSFC static test tower early in October. On October 10 a successful eight-engine, 33-second test (SA-04) was performed to check reliability and performance of booster and gimbal systems. Test SA-05 was successfully conducted on October 24 for a duration of 112 seconds. Test objectives included evaluation of the flight cutoff sequence.[33]

Late in October NASA selected a 13,550-acre site in Mississippi on which to build a facility for static testing Advanced Saturn and Nova first stages. This location of the Mississippi Test Facility is only 35 miles from the Michoud Plant

where industry would manufacture the S-I and S-IC stages.[34]

The first launch of the Saturn vehicle took place on October 27, 1961. The vehicle, 162 feet high and weighing 460 tons at liftoff, rose to a height of 85 miles during its journey. The inboard engines shut down after 109 seconds of burning; the outboard engines cut off six seconds later. The booster stage produced the 1,300,000 pounds of thrust intended for the first four flight tests. (On subsequent tests, the thrust would be increased to 1,500,000 pounds.) At a speed of approximately 3600 miles per hour the Saturn followed a precalculated flight path to land within 13 miles of predicted impact, over 214 miles from Cape Canaveral. The launch was considered almost flawless.[35]

On November 6, 1961, MSFC directed North American to redesign the S-II stage to incorporate five J-2 engines, providing a total of 1,000,000 pounds stage thrust.[36]

Work at the new large-booster static test stand at MSFC was interrupted in November for redesign of the stand to accept thrust levels of more than 7.5 million pounds.

On November 10, 1961, NASA received proposals from five firms for the development and production of the advanced Saturn booster.

NASA announced selection of Chrysler Corporation on November 17 to negotiate a contract to build, check out, and test 20 S-I boosters. These boosters would be manufactured at the Michoud Plant. The contract was signed in mid-January 1962.[37]

On November 19 the nation's first liquid hydrogen engine, the RL10, successfully completed its preliminary flight rating test. Producing 15,000 pounds thrust, the engine, designed and developed by Pratt & Whitney, performed about 30 percent

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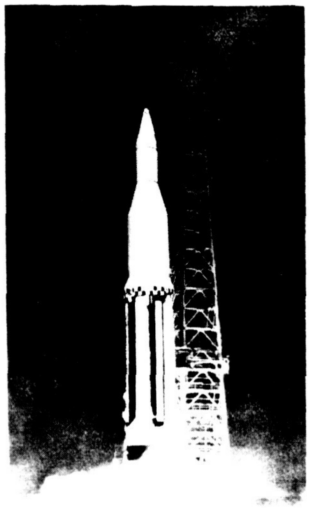

86. Launch of Saturn SA-1 flight vehicle
87. S-II stage cutaway

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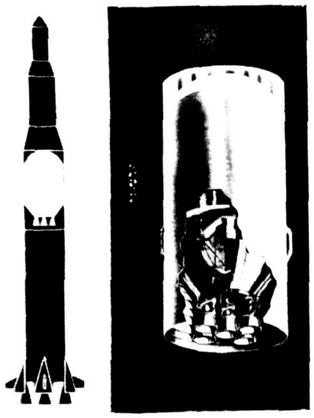


better than engines using hydrocarbon fuels. Six such engines would power the Saturn S-IV stage.

After this progress in arranging for development of a large launch vehicle NASA, on November 29, 1961, awarded North American Aviation a contract for the design and construction of its payload, a three-man spacecraft.

Marshall Space Flight Center and Manned Spacecraft Center planned to use the C-1 research and development vehicles for vehicle-payload compatibility tests and early systems tests of the spacecraft. The spacecraft was designated Apollo, also the name of the Saturn vehicle missions project.

The Apollo project would be divided into three basic missions: earth orbital flights, circumlunar flights, and manned landings on the moon. The two-stage Saturn C-1 was to support earth-orbital flights of prototype Apollo command modules during the 1964-1965 period. The advanced Saturn C-5 would support reentry and circumlunar Apollo flights.

Meanwhile, the SA-T3 test stage was installed in the test stand. On November 30, 1961, MSFC conducted a test to investigate flight cutoff sequencing, perform an "engine out" test, and study fuel and LOX tank levels. The test was prematurely cut off at 95 seconds by the automatic fire detection system. No hardware damage occurred. This was the first of a series of tests to verify SA-3 design improvements.[38]

The last of the Saturn 70-inch tanks to be manufactured by MSFC was completed the week of December 4. Future 70-inch tanks would be built by Chance-Vought in Dallas, Texas, and shipped initially to MSFC and later to Michoud for the Chrysler assembled stages.

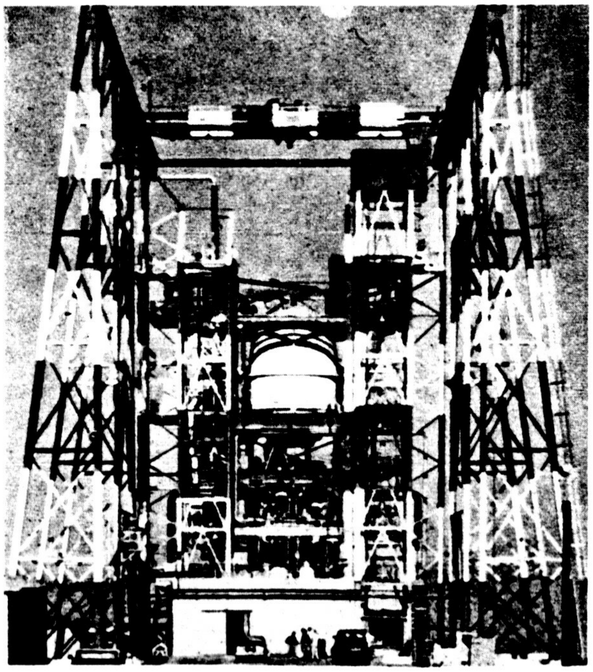
On December 5, 1961, Atomic Energy Commission (AEC)-NASA Space Nuclear Propulsion Office

selected the Aetron Division of Aerojet-General Corporation's proposal as the basis for a Nerva engine test stand contract. The Nerva would be used in nuclear stages with a reactor derived from the Kiwi-B test series. Two days later a pre-proposal conference was held at Huntsville, Alabama, to select a prime contractor for the reactor-in-flight test (RIFT) stage launch vehicle. The RIFT vehicle, planned for use as an upper stage of a Saturn vehicle, would be powered by the Nerva nuclear engine.[39]

Marshall awarded a design contract on December 6 for modification to the west side of the Center's existing static test tower. The tower, scheduled for completion by the summer of 1963, would be used for acceptance testing of Chrysler S-I stages.

At the Douglas Sacramento Test Facility (SACTO), prototype S-IV stage tankage was installed and propellant loading tests begun on December 11, 1961.

Marshall completed modifications to the Saturn



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88. S-IV tankage at SACTO test facility

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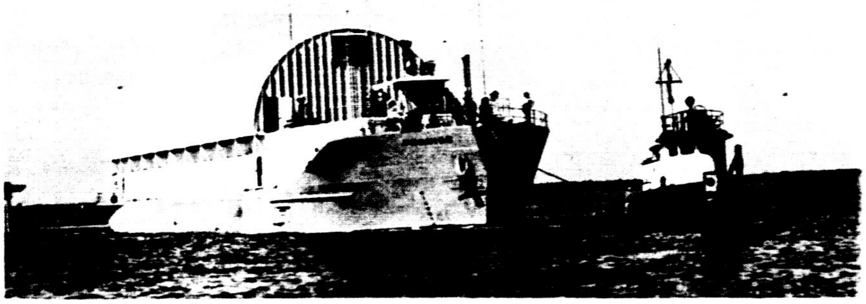

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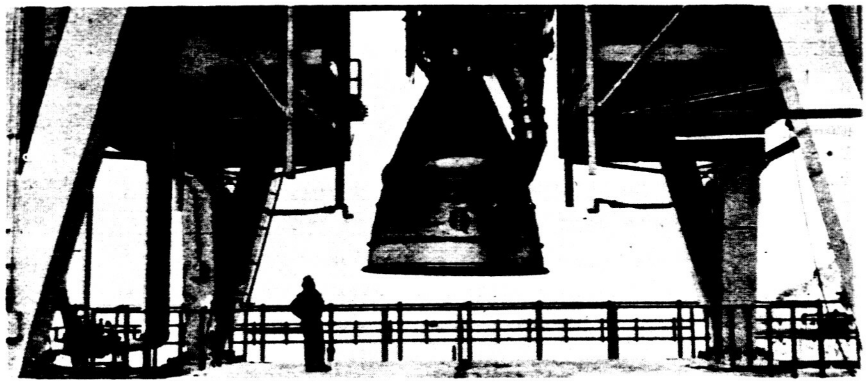
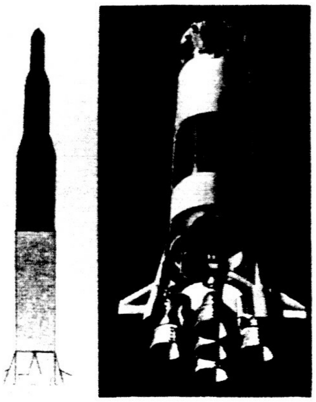


89. Barge Promise
90. F-1 engine and test stand
91. S-IC stage

91



barge Compromise on December 14, 1961. The barge, renamed Promise, was readied for movement to Wheeler Dam where it would receive stages of the SA-2 flight vehicle. On the same day another F-1 engine test was performed at the Rocketdyne test facility. The engine reached its rated 1.5 million pounds thrust in a short mainstage firing.

NASA selected the Boeing Company on December 15 as a possible prime contractor for the first stage (S-IC) of the advanced Saturn vehicle.[40] The S-IC, powered by five F-1 engines, would be 33 feet in diameter and about 140 feet high. The manufacturing program at Michoud was to produce 24 flight stages and one ground test stage.[41] In December MSFC awarded a contract to the Mason-Rust Company to perform housekeeping and other administrative services at the New Orleans Michoud Plant.

NASA selected Douglas Aircraft on December 21, 1961, to negotiate a contract to modify the Saturn S-IV stage by installing a single J-2 Rocketdyne engine of 200,000 pounds thrust. The modified stage, identified as the S-IVB, would be used as a third stage of the advanced Saturn C-5 configuration.[42]

On December 28, the Mississippi Test Facility was officially named Mississippi Test Operations by Dr. Robert C. Seamans of NASA Headquarters.

Assembly of the SA-4 flight booster began January 2, 1962. The SA-3 booster successfully completed functional and pressure engine tests and entered pre-static checkout on January 8, 1962.[43]

NASA announced on January 24 that Aerojet-General Corporation had been selected for design and development of a new liquid hydrogen engine. The engine, known as the M-1, was to power the second stage of the Nova launch vehicle. Its thrust would be 1,200,000 pounds.

MSFC awarded a contract to Consteel-Ets-Hokin late in January for the construction of the umbilical tower for Launch Complex 34 at Cape Canaveral. The tower would carry the electrical, pneumatic, and hydraulic connections used in fueling and servicing upper stages.[44]

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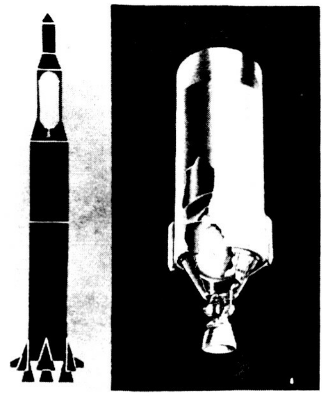

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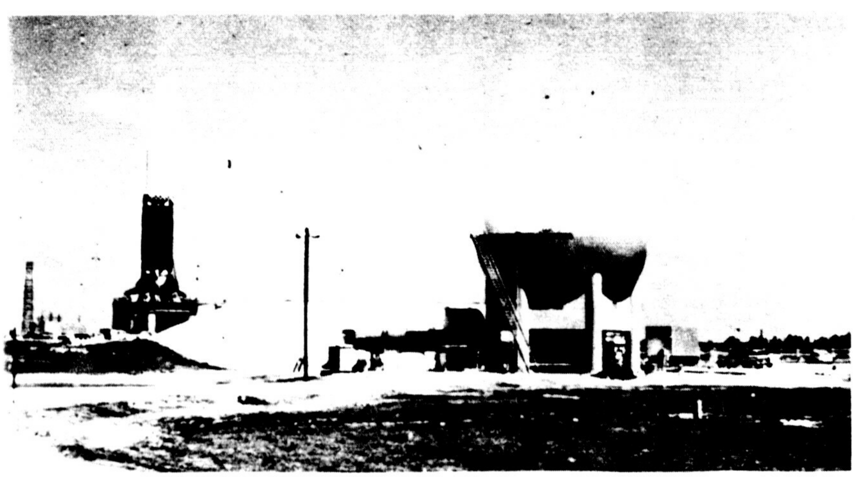

92. S-IVB stage cutaway
93. Saturn C-5
94. SA-2 erected on launch pedestal

On January 25, 1962, NASA approved development of the three-stage Saturn C-5 vehicle under the direction of MSFC. The vehicle would support manned circumlunar flights and manned landings by earth or lunar orbit rendezvous method. The C-5 was expected to be capable of placing 120 tons in low earth orbit or escaping 45 tons to the vicinity of the moon. [45]

On February 6, 1962, a 46-second C-1 booster test firing was successfully conducted at MSFC. Stages of the Saturn SA-2 flight vehicle departed Huntsville on February 16 for Cape Canaveral. The vehicle arrived at Cape Canaveral on February 27, 1962, and by March 1 the vehicle was erected on the launch pad of Launch Complex 34. A static firing of the SA-T3 booster was conducted on February 20, 1962. The test, scheduled to last until LOX depletion cutoff, was terminated at 55 seconds due to fire indication at engine No. 6. No damage resulted. [46]

On February 9 a preliminary contract was awarded the Space and Information Systems Division (S&ID), North American Aviation, to design, develop, and fabricate the S-II stage of the C-5 vehicle. MSFC signed a preliminary S-IC development contract with Boeing Company on February 14. [47]

On March 4 NASA selected Sverdrup Parcell Company to provide design criteria and initial planning for the test facilities at the Mississippi Test Operations. [48]

On March 19 the booster for the SA-3 flight vehicle was installed in the test tower, and preparations were begun for the first flight qualification test. [49] At Douglas Aircraft structural assembly of the first all-systems vehicle was completed in March 1962. The all-systems vehicle, a heavily instrumented configuration of the second (S-IV) stage, would be used to check out all operating S-IV systems.

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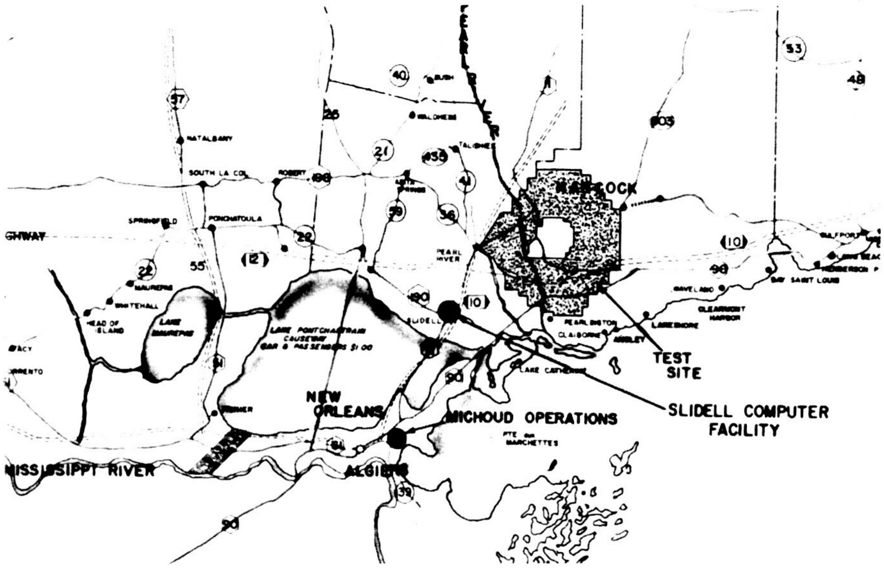
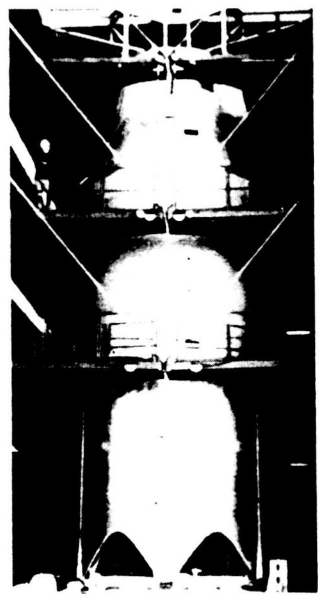


95. *Regional map showing Mississippi Test Facility*
96. *S-IV All-systems vehicle*

96



On March 19, 1962, the Seal Beach, California, site was reconfirmed as the location of the S-II stage major manufacturing and assembly activities. Testing of prototype stages would be performed at Santa Susana, California. Stage acceptance testing would be conducted at the Mississippi Test Operations. Late in March a construction contract was awarded for construction of a second launch area at the Saturn Launch Complex 37, Cape Canaveral. Construction began early in April.

On April 10, 1962, the SA-3 booster successfully performed its first flight qualification test in a static firing of 31 seconds' duration.[50] On the same day representatives of 13 companies attended a preproposal conference at MSFC concerning the Nova launch vehicle designs. Submittal of bids was required late in the month.

The large liquid hydrogen engine, J-2, which would power the S-II and S-IVB stages for advanced Saturn vehicles, reached 90 percent sea-level thrust in its initial hot firing tests on April 11. On the same day the huge F-1 engine, being developed to power the S-IC stage, performed a successful 150-second static firing.[51]

In mid-April reconstruction of the Wheeler Dam Lock on the Tennessee River was completed; transportation of Saturn flight stages could be made without land detour.[52]

NASA Headquarters announced on April 18 that the highest national priority (DX) had been approved for the Apollo, Saturn C-1, and Saturn C-5. The priority included all stages, engines, facilities, and related construction for production, test, research, launch, and instrumentation.[53]

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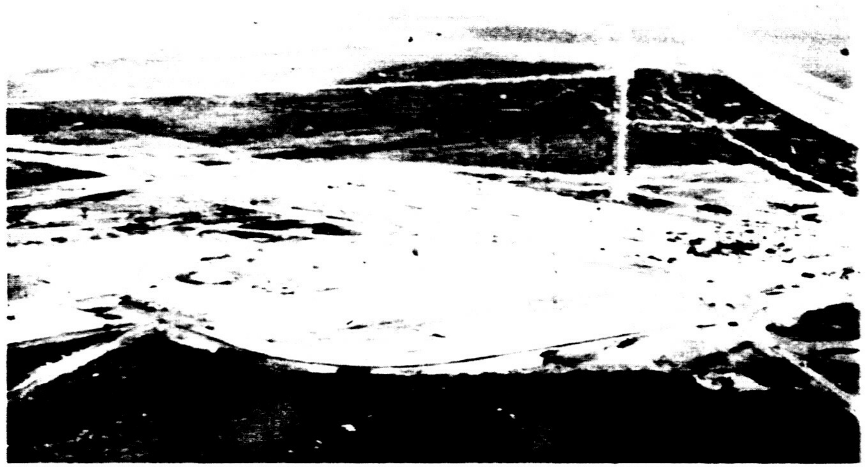

97. Construction of Launch Complex 37

98. Launch of Saturn SA-2 Flight Vehicle

98

NASA launched the second Saturn flight vehicle, the SA-2, from Cape Canaveral on April 25. As with the SA-1, the vehicle was launched without a technical hold during the 10-hour countdown. This vehicle had a secondary mission. After first stage shutoff at 65 miles altitude the water-filled upper stages were exploded, dumping 95 tons of water in the upper atmosphere. The massive ice cloud produced rose to a height of 90 miles. The experiment, called Project High Water, was performed to investigate the effects on the ionosphere of the sudden release of such a great volume of water. This experiment did not interfere with the major goal of the flight which was achieved when the first-stage engines burned out 116

seconds after launch. Every phase of the flight was considered successful.[54]

A 31-second duration eight-engine test of the SA-3 flight booster was conducted on May 17 with excellent overall performance.[55] The final SA-3 booster acceptance firing test was performed on May 24 for a duration of 119 seconds.[56]

On May 26, 1962, Rocketdyne successfully conducted the first full-thrust, long-duration F-1 engine test. On the same day SA-4 booster fabrication was completed.[57]

In mid-May MSFC directed Douglas to produce a 260-inch-diameter S-IVB stage. The increase of 40 inches over the initially planned diameter permitted development of a more optimum sized

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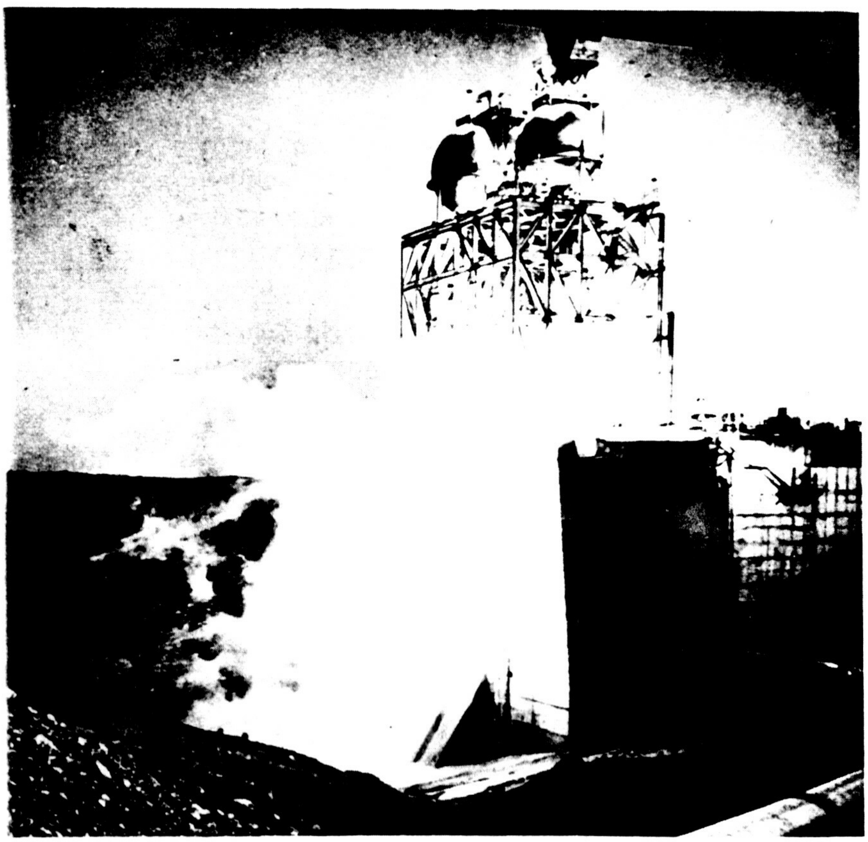

99. *Static firing of F-1 engine*

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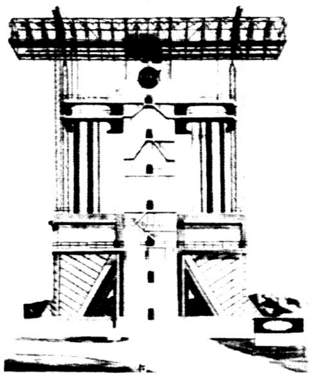

100. C-1 first stage test stand
101. Saturn C-IB vehicle

101

stage. Also during May the Center decided to increase S-II stage length from 75 feet to 81.5 feet and decrease the S-IC stage length from 141 feet to 138 feet.

On June 5 MSFC contracted to modify the Saturn C-1 booster static test stand at MSFC. The stand, originally built to test the Redstone and Jupiter missiles and later modified for Saturn testing, would provide test positions for two C-1 first stages.[58]

On June 9 Pratt & Whitney completed preliminary flight rating tests of the RL10-A-3 engine for the Saturn C-1 second stage. All test objectives were successfully met. At MSFC the first SA-4 test booster static firing was successfully conducted on June 18 for a duration of 31 seconds.[59]

During June bids were requested for construction of a static test stand to captive fire the Saturn C-5 booster. The stand, to be located at MSFC, would provide handling equipment and thrust restraint for boosters up to 178 feet in length, 48 feet in diameter, and with thrust of up to 7.5 million pounds. Including a crane at the top, the tower would stand 405 feet high, more than twice as tall as the present Saturn C-1 booster test stand.

NASA and Rocketdyne signed letter contracts on July 2 for further development and production of the F-1 and J-2 engines. The contracts, extending through 1965, cover long lead-time items in F-1 engine research and development and early production effort on F-1 and J-2 engines. On July 7 SA-5 flight booster assembly began at MSFC.[60]

A new Saturn vehicle was needed. NASA announced on July 11 that a new, two-stage Saturn-class vehicle would be developed for manned earth-orbital missions with full-scale Apollo spacecraft.[61] The Saturn would be known as the Saturn C-1B. Simultaneously, NASA announced selection of lunar orbit rendezvous as the method

for performing the manned lunar landing. This lunar rendezvous mode would require the use of only one Saturn C-5 vehicle to inject the spacecraft into an earth-lunar trajectory. The entire Apollo spacecraft would not land on the moon after its separation from the launch vehicle's third stage. Rather, one unit of the spacecraft, a lunar excursion module, or "bug," would land and later rejoin the rest of the orbiting Apollo.

Meanwhile, progress on Saturn C-1 continued. On July 12 the second static test of the SA-T4 stage was manually terminated after 12 seconds; a broken ground instrumentation wire had caused an erroneous pressure drop indication. Pressure measurement loss caused a premature cutoff of a third SA-T4 static test conducted on July 13. A fourth firing of 120 seconds duration was conducted on July 17; overall performance was excellent. The stage was removed from the test stand on July 20, and MSFC began uprating the engines to 188K thrust level. The uprated stage was redesignated the SA-T4.5.[62]

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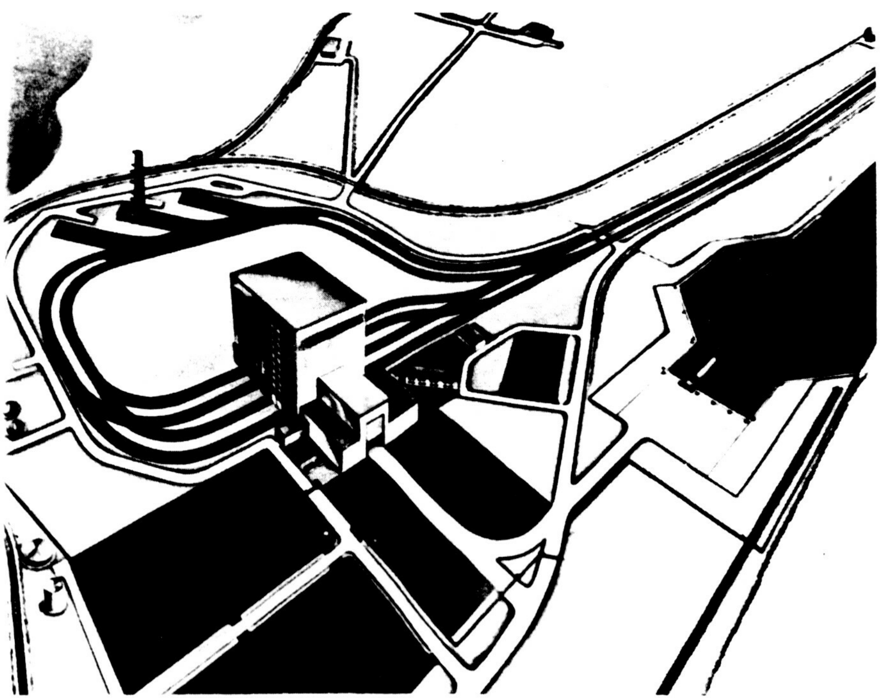

102. Launch Complex 39

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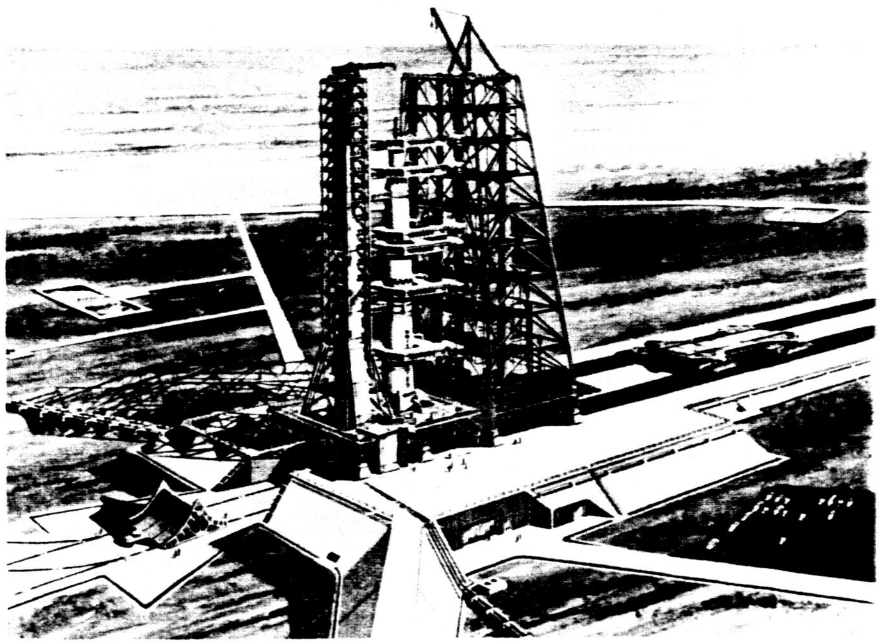

103. *Saturn C-5 launch pad*

On July 21 NASA Headquarters announced construction plans for Launch Complex 39, Saturn C-5 launch facilities. The 350-foot-high vehicle would be erected and checked out vertically in a special 48-story assembly building. Following checkout a 2500-ton crawler vehicle would move the Saturn C-5 to its launch pad.[63]

In July NASA announced that a computer center would be established at Slidell, Louisiana, to service the Michoud Operations. The Center, to be one of the nation's largest, would perform engineering calculations necessary in the development, building, and static testing of the Saturn C-1 and C-5 boosters.

To assure C-5 strength, MSFC awarded a design contract in July for a 360-foot-high dynamics test tower. The Saturn C-5 launch vehicle would be suspended in the tower and vibrated by mechanical and electrical means. This simulation of free-flight conditions would determine the vehicle's natural bending modes.[64]

On August 6, 1962, NASA and Chrysler Corporation signed a contract for production of 21 C-1 boosters, to be delivered between late 1964 and early 1966. The stages would be produced by Chrysler at the Michoud Plant near New Orleans.[65] On the same date NASA announced that the Boeing Company had received a supplementary contract from MSFC for work leading to design, development, fabrication, and test of the C-5 booster.

A C-5 second stage contract for design, development, fabrication, and testing of the S-IVB stages was awarded Douglas on August 8. The contract called for 11 of the stages: five for ground tests

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(two of which would be used later as inert flight stages) and six for powered flight.[66]

Next, provision was made for C-5 guidance and control. On August 13 MSFC selected the C-5 instrument unit design. The cylindrical unit would measure 260 inches in diameter and stand 36 inches high. All vehicle guidance and control equipment would be mounted on panels fastened within this structure.

On August 15 NASA awarded Rocketdyne Division a two-year contract to continue H-1 engine research and development. These first Saturn

104. NASA Computer Center, Slidell, Louisiana
105. C-5 Dynamic Test Tower

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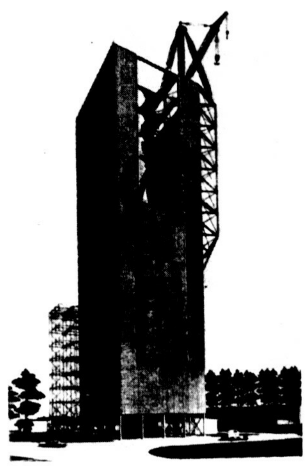

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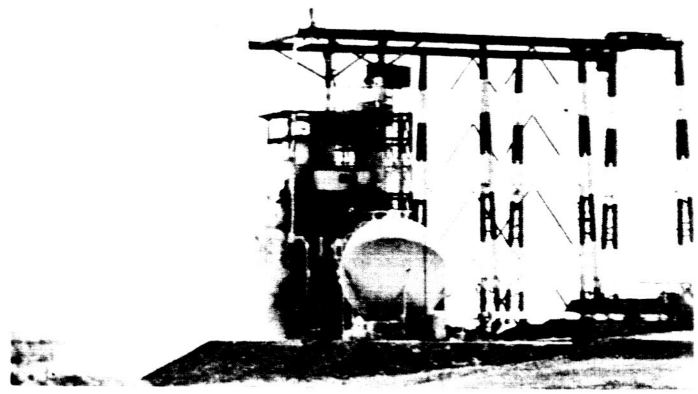
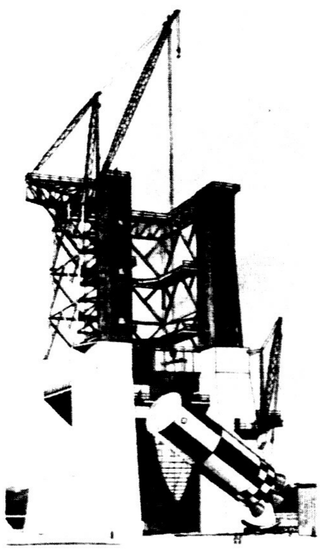


106. S-IV battleship static firing
107. S-IC static test stand

107



booster engines would also be used in Saturn IB boosters.

C-1 second stage progress continued. On August 17 Douglas performed the first S-IV battleship static firing at the Sacramento Test Facility in California. The stage developed approximately 90,000 pounds of thrust for a planned 10 seconds duration; all test objectives were met. A successful full 420-second firing was performed on October 4. In the final phase of testing a total of 11 tests were conducted, the last one on November 8.

MSFC on August 31 awarded a contract for construction in Huntsville of the S-IC static test stand superstructure.[67] During August Phase I construction of the Launch Complex 34 umbilical tower was completed at AMR. Also in August, MSFC received the Douglas preliminary proposal covering modification of the S-IVB stage for use in the C-1B vehicle.

The SA-3 flight booster was shipped to Cape Canaveral on September 9, arrived on September 19, and was erected on the launch pad on September 21.[68] By September 24 the inert upper stages and payload had been erected on the booster.

Early in September ground breaking ceremonies were held at Seal Beach, California, where assembly and test facilities for the second (S-II) stage of Saturn C-5 would be. The S-II facility would be constructed by the Navy and operated by North American Aviation's S&ID.

On September 11 President Kennedy and Vice President Johnson, with other key Government officials, visited MSFC as part of a two-day tour of four U. S. space centers.

On September 15 Michoud technicians installed a 42-foot boring mill, the largest known, for use in C-5 production.[69] Also in mid-September, MSFC provided Douglas 90-day program authorization to investigate minimum changes necessary to adapt C-5 second stages to C-IB. Douglas would also study attachment of the S-IVB stages to the C-1 booster, as well as separation during flight.

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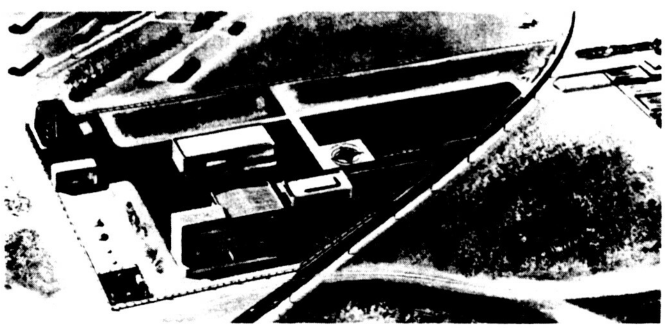

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108. S-II stage assembly and test facility
109. President Kennedy visits MSFC

110. Installation of 42-foot boring mill
111. Mississippi Test Facility

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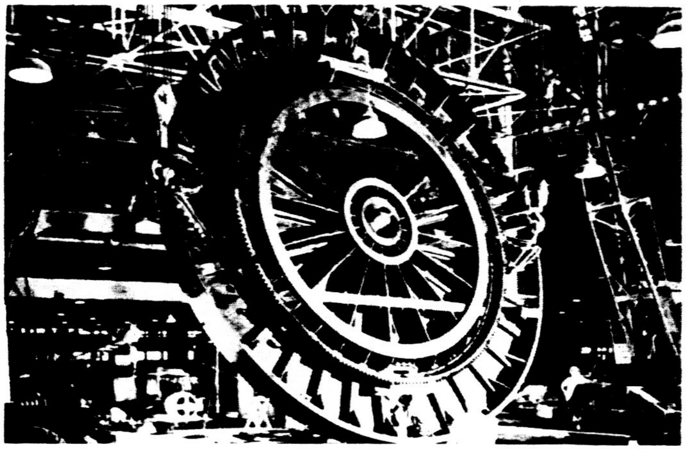

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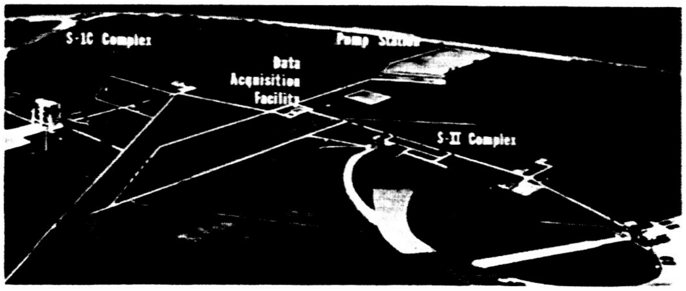

On September 25 assembly began of the SA-6 flight booster. Meanwhile, preliminary plans were completed for development of the Mississippi Test Operations. First phase of the three-phase program included building two test stands each for static firing the S-IC and S-II stages and about 20 service and support buildings. Improvement of approximately 15 miles of river channel and construction of a canal within the test facility would permit transportation of stages from Michoud to Mississippi Test Operations test stands.

All objectives were met during the second SA-4 booster flight qualification static firing on September 26. A record burning time was set when the inboard engines operated for 121.5 seconds and the outboard engines for 127.43 seconds. The SA-4 booster was removed from the static test tower on October 1; post-static checkout began.[70] On the same day MSFC let a contract for construc-

tion of the vertical assembly building foundation at Michoud.[71]

During September MSFC directed S&ID to develop a plan for C-5 dual plane separation. In dual plane separation, S-IC separation would be followed by separation of the S-II interstage.

The first industry-produced booster was started October 4 at Michoud when Chrysler began fabrication of S-I-8, the first of 21 Saturn C-1 boosters it was scheduled to produce.

Two J-2 engine full-thrust firing tests, of 50 and 94 seconds duration respectively, were successfully performed prior to a long-duration static firing on October 4. The long-duration engine test conducted by Rocketdyne was satisfactory throughout the scheduled 250 seconds operation.[72] A second long-duration test of 220 seconds was successfully conducted on October 6 at the Santa Susana Test Facility.

During October MSFC began tests on the C-1 uprated test stage SA-T4.5. Tests were to check the integrity of the propulsion system and effect of the 188K engines on the flame deflector. After tests were successfully concluded the stage went to Michoud for use in checking out facilities.

MSFC awarded a Saturn C-5 contract on October 5 for construction in Huntsville of a combined S-IC stage vertical assembly building and hydrostatic test tower.[73] NASA Headquarters approved on October 12 the Saturn C-5 second stage (S-II) long-term research and development contract with S&ID.[74]

On October 15 NASA Headquarters approved the Saturn C-5 vehicle development schedule, Plan V.[75] The plan includes funding and test program adjustments, assembly of the first S-IC flight stage at MSFC, and launch and ground test schedule changes.

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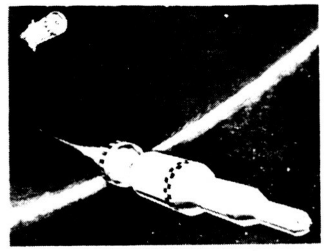

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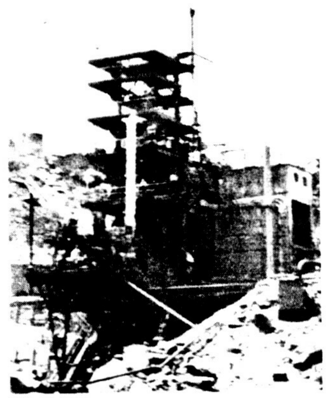

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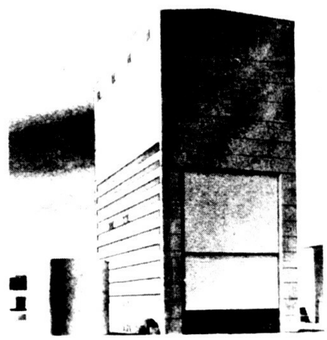

112. Dual plane separation
113. J-2 test facility
114. S-IC Stage facility

115. SA-5 congiguration
116. Unloading S-IV stage at MSFC

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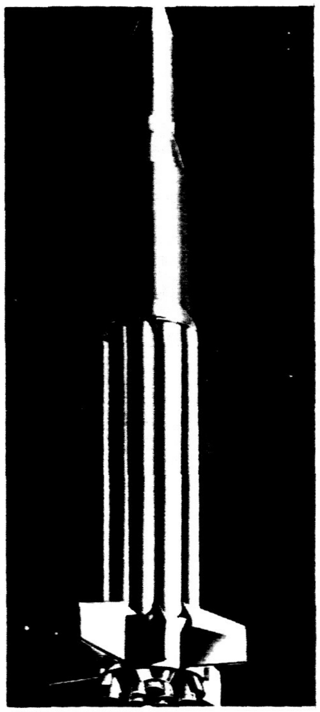

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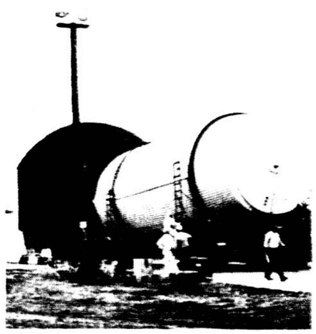

In October NASA arranged to dredge an access channel to the Saturn C-5 Complex 39 Vertical Assembly Building and Launch Pad area at Merritt Island, Florida. On October 2 MSFC contracted for construction of a flame deflector for the MSFC Saturn S-IC test stand.[76]

During October MSFC decided to fly a Jupiter-type payload with the fifth Saturn flight.[77] Saturn C-1 second stage progress included completion of the S-IV Hydrostatic/Dynamics Stage at Santa Monica. It began its trip to MSFC via the Victory Ship Smith Builder on October 26, was transferred to the barge Promise at New Orleans, and delivered to MSFC on November 16 for six months of comprehensive dynamic testing.[78]

The Launch Operations Center awarded a contract in October to modify the Complex 34 fuel, LOX, and liquid nitrogen servicing systems in preparation for Saturn C-1 Block II vehicle launches. SA-5 flight booster assembly was completed on November 6 and the booster transferred for pre-static checkout.[79] Assembly of the SA-D5 booster for dynamics testing was completed on October 29. This stage was installed in the MSFC dynamics test tower on November 13, 1962. The SA-D5 booster simulated configuration of the final Saturn C-1 boosters which were expected to be used for manned flights.

During November Douglas awarded subcontracts for development of the S-IVB's 1750-pound thrust ullage motors and 150-pound thrust attitude control motors.

On November 8 the last S-IV battleship test with RL10-A-1 engines was completed at SACTO; 11 tests totaling 1137.6 seconds were accomplished. The A-1 engines were then removed and installation began of RL10-A-3 operational-type engines for the next phase of battleship hot firing tests.[80]

Cost negotiations between MSFC and Boeing began

on November 15 for the long-term S-IC stage development and production contract.

The third Saturn flew on November 16. SA-3 was successfully launched from Cape Canaveral, carrying a full propellant load of 750,000 pounds. It rose to a height of about 104 miles. Flight range was 131 statute miles. Inboard engine cutoff occurred as planned after 141 seconds of flight; outboard engine cutoff came eight seconds later. Project High Water was performed as a secondary mission on SA-3 as on SA-2.[81]

On December 13 a contract was awarded for the construction of the Michoud S-IC Hydrostatic Test and Vertical Assembly Building. Also at Michoud, Chrysler Corporation began fabrication of the tenth and final research and development Saturn booster, S-I-10.[82]

In December design of Marshall's C-5 Dynamic Test Tower was completed; Douglas awarded a contract for fabrication of the S-IVB battleship tank; and, at Cape Canaveral, the Corps of Engi-

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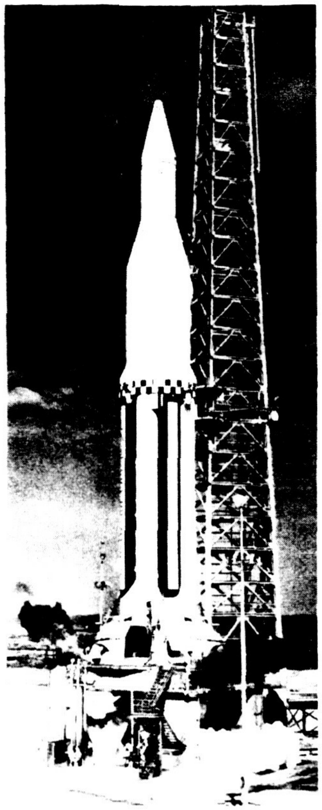

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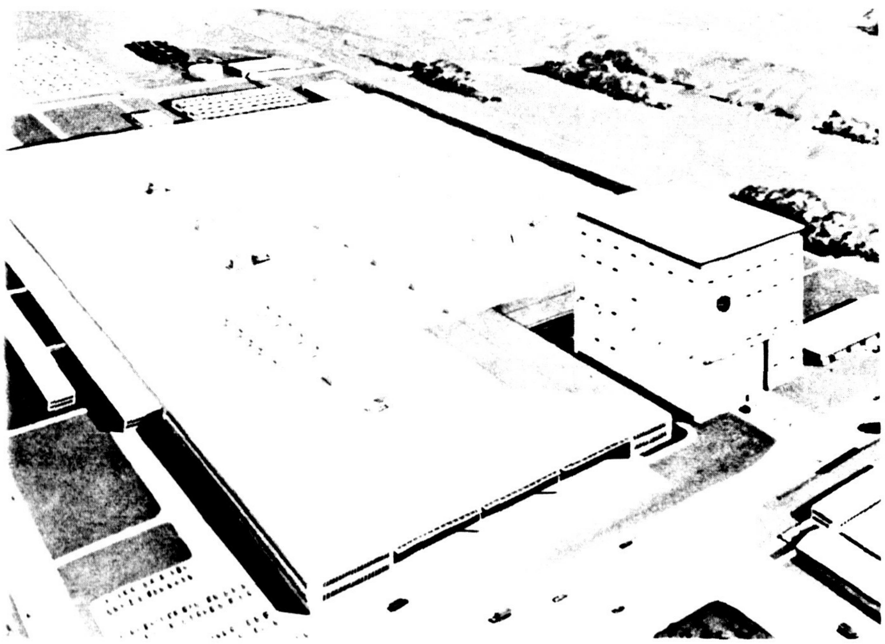

117. Launch of SA-3 Flight Vehicle
118. Vertical Assembly Building at Michoud

neers awarded a contract for design of the Launch Complex 39 Vertical Assembly Building.

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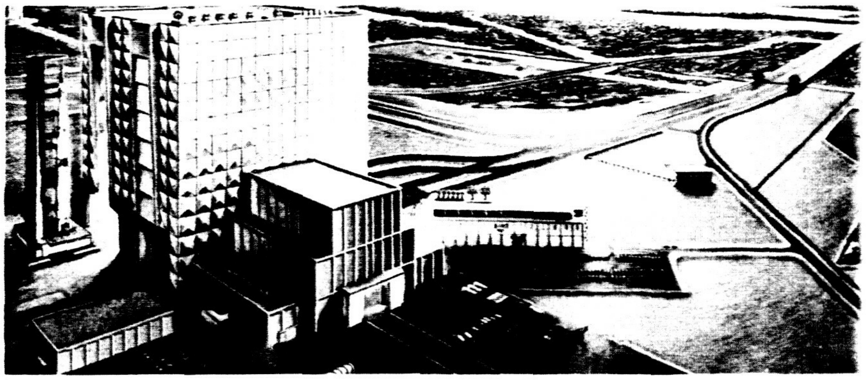

119. Launch Complex 39 Vertical Assembly Building
120. SA-D5 booster

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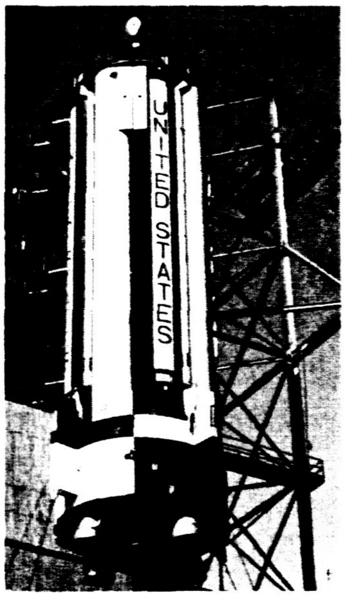

Initial checkout of the S-IV all-systems vehicle began at Santa Monica in late December.[83] Douglas began fabrication of S-IV-111, the first production S-IV flight stage.

Rocketdyne studied causes of the F-1 engine combustion instability first encountered during June 1962. Testing with modified engine hardware began in the latter part of 1962 and was scheduled to continue during 1963.[84]

During early January 1963 construction began at the Huntington Beach Assembly Facility where Douglas Aircraft Company will assemble S-IVB stages.

In January MSFC began dynamics tests of the SA-D5 vehicle configuration.[85] The Center finished expansion of its static test tower for Saturn C-1 Block II first stages.

Douglas completed checkout of the S-IV dynamic/ facilities vehicle at Santa Monica and, during January, sent this vehicle to Cape Canaveral for use in checkout of Launch Complex 37B facilities.[86]

MSFC shipped by barge the complete SA-4 vehicle from Huntsville to Cape Canaveral. The complete vehicle was erected on Launch Complex 34 by February 5.[87]

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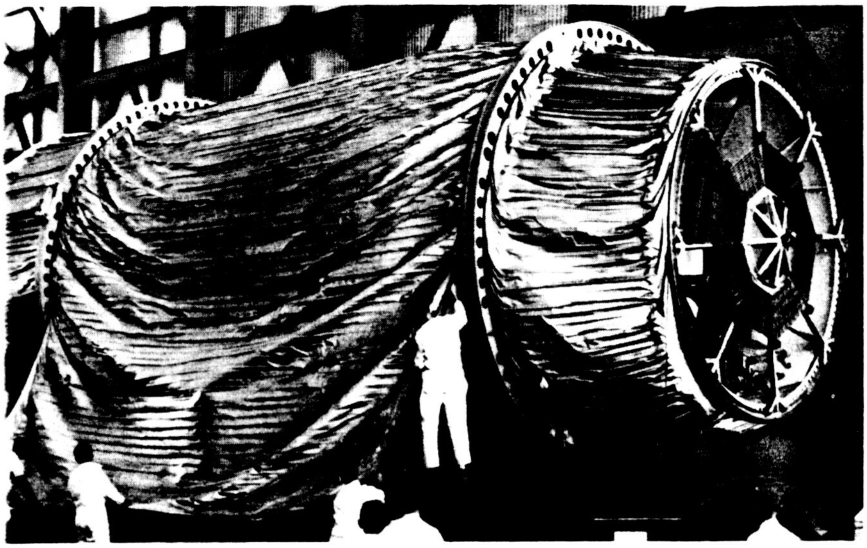

On January 26 at SACTO, Douglas static fired the RL10-A-3-powered S-IV battleship vehicle. Test duration was 468 seconds.[88] On February 1 Douglas shipped the S-IV all-systems vehicle from Santa Monica to SACTO for testing.[89] At Launch Complex 37B the launch control center, automatic ground control station, and umbilical tower were completed on January 30.

During the first week of February NASA Headquarters announced a change in Saturn vehicle nomenclature. Saturn C-1 became Saturn I, Saturn C-IB became Saturn IB, and Saturn C-5 became Saturn V.[90]

Saturn V hardware development was under way. In early February Boeing began S-IC bulkhead gore-forming operations at Wichita, Kansas.[91]

On February 4 MSFC decided to modify the west side of the MSFC static test tower for F-1 engine testing. The modification would allow single F-1 engine tests to begin several months earlier than scheduled. The stand would later be reconverted for S-I static testing. On February 8 MSFC awarded a contract for construction of a single F-1 engine test stand superstructure at MSFC.

121. S-IV Dynamic/Facilities stage at Cape Canaveral
122. SA-4 on Launch Complex 34

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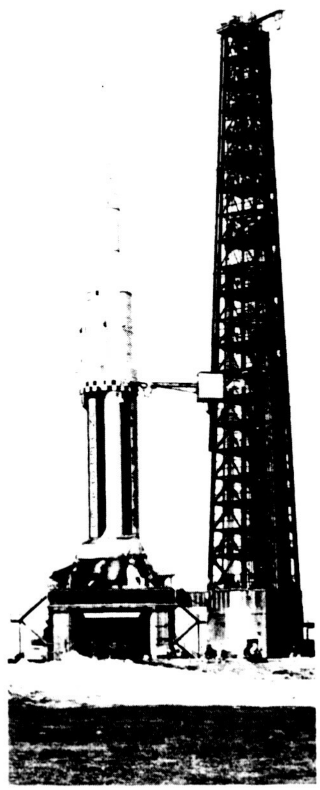

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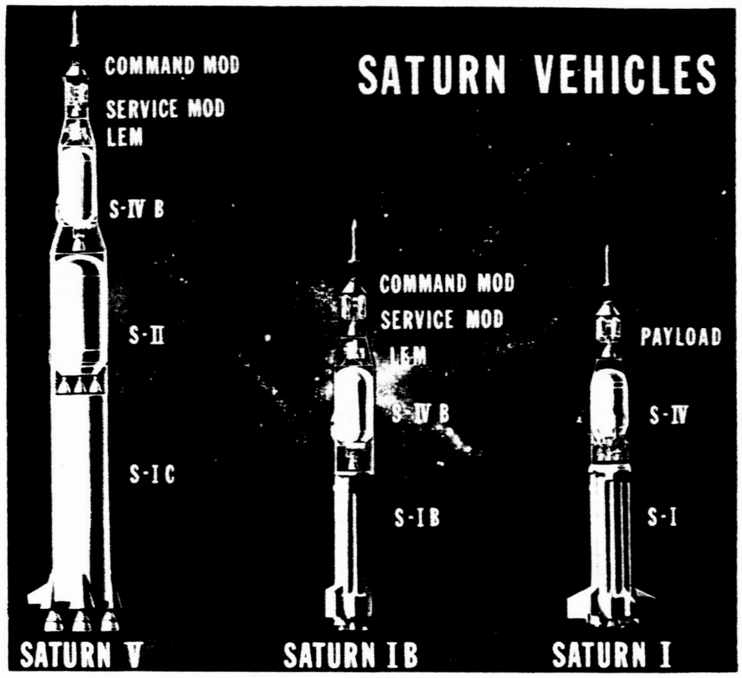

123. Saturn Vehicles
124. S-IC bulkhead gore forming
125. F-1 test stand

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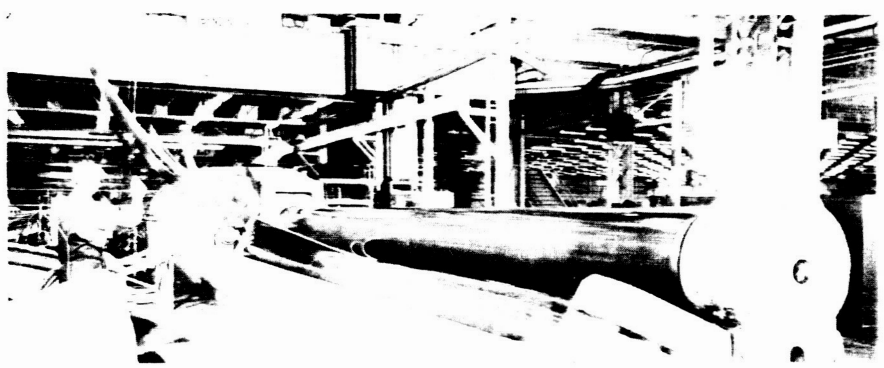

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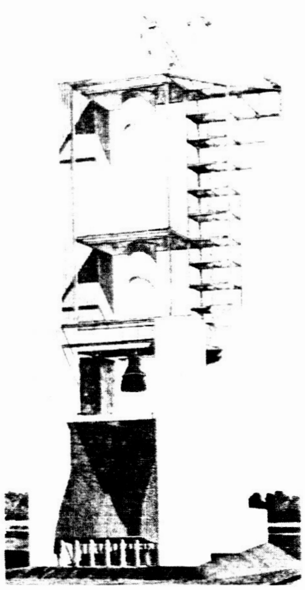

Early in February S&ID began occupancy of the Seal Beach assembly and test facility where Saturn V second stages would be assembled and tested. Also in February S&ID successfully completed S-IC/S-II stage dual plane separation impingement tests.[92]

The first live Saturn I second stage would be powered by liquid hydrogen, still not flight proven. The S-IV battleship stage permitted tests of this

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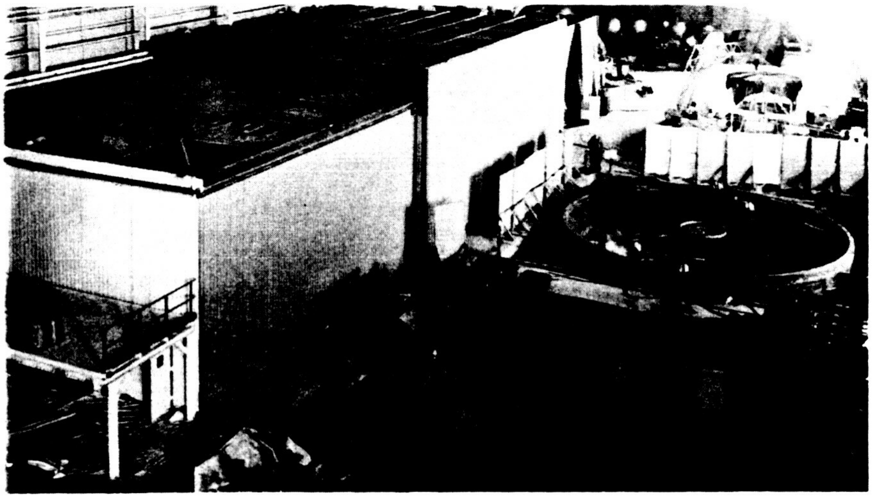

126. S-II Seal Beach facility
127. Crawler-transporter

new technology. On February 18 and 19 S-IV battleship turbine spinup tests were unsuccessful due to inadequate purge procedures; however, on February 23 a successful spinup test was accomplished. Two days later the second battleship firing testing RL10-A-3 engines was terminated after 6.5 seconds when a hydrogen leak caused a fire at engine No. 4. No damage resulted.[93]

On February 20 NASA began contract negotiations for design, fabrication, erection, and testing of

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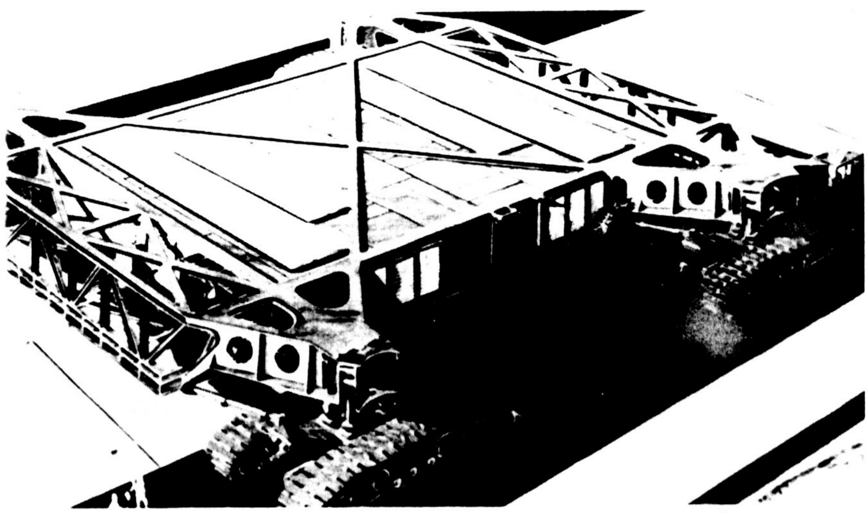

the crawler-transporter which would transport the Saturn V vehicle to the launch pad of Launch Complex 39. The contract was signed on March 29, 1963.

NASA Headquarters on February 20 approved the plan for modification of the basic Chrysler contract. The plan provides for redesign of the S-I stages.[94]

For Saturn V, NASA Headquarters approved the Boeing S-IC definitive contract on February 21. Boeing will design, develop, and manufacture one ground test stage and nine flight stages at the Michoud Plant in New Orleans.[95] On February 27 the Corps of Engineers awarded a design contract for the Saturn V test facilities at the Mississippi Test Operations.

MSFC awarded a contract in February for construction of three micrometeoroid satellites, two for flight and one for backup.[96] The satellites,

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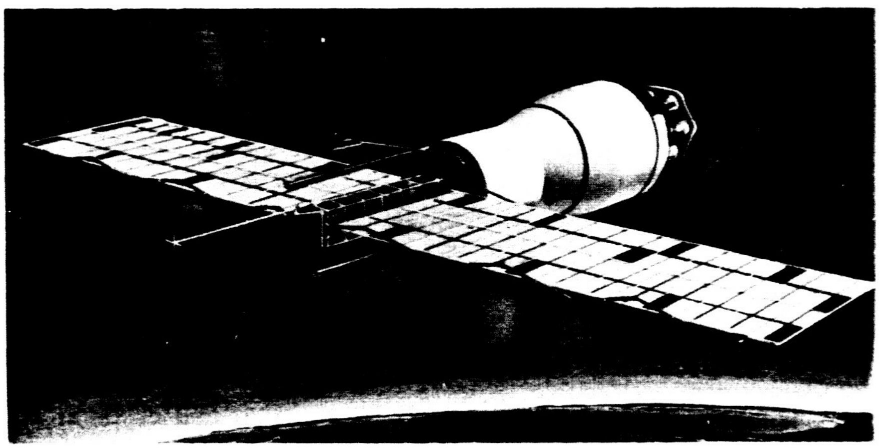

128. Micrometeoroid satellite

secondary payloads for Saturn I vehicles SA-8 and SA-9, would be used to obtain data on frequency and penetration of micrometeoroids in low earth orbits and to relay the information back to earth. On February 27 the first S-I-5 flight qualification static test (SA-11) was successfully conducted at MSFC for a planned duration of 32 seconds.

On February 19 at the Michoud Plant, Boeing completed the first Y-ring for the S-IC test fuel tank; on March 4 the Y-ring was delivered to MSFC where the fuel tank would be assembled.[97] Also at Michoud during February a contract was awarded for design and construction of the engineering building.

During February, construction of Test Stand 2B at SACTO was completed and the propellant pneumatic systems were installed and checked out.

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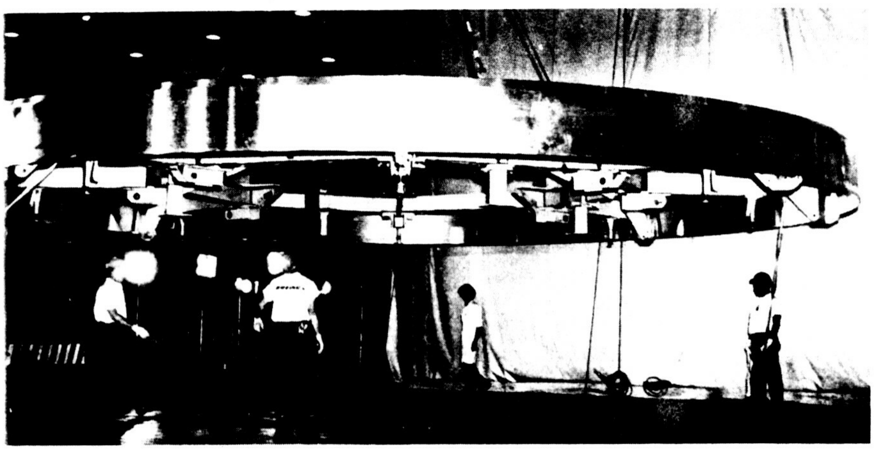

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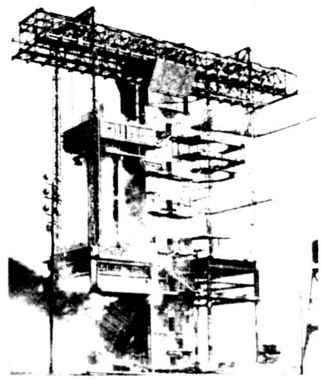

129. Static firing of S-I-5
130. Completed Y-ring at Michoud
131. Explosive forming dies

On March 1 Rocketdyne successfully gimballed an F-1 engine during a hot firing test in California.[98] On the same day qualification of explosive forming dies for S-II gore segments began at North American's El Toro Facility.

S&ID awarded a construction contract for the electro-mechanical mockup at Downey, California, on March 1; the mockup will be used for design and engineering verification of various S-II systems. On March 8 MSFC awarded a one-year contract to industry for operation of the Slidell Computer Facility at Slidell, Louisiana.

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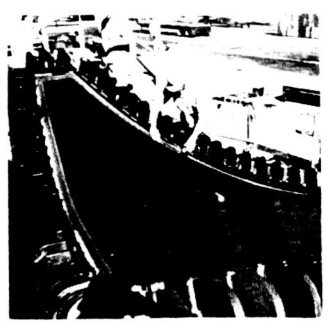

Dynamic testing of the SA-D5 vehicle was completed on March 7.[99] On March 13 a second flight qualification static firing of S-I-5 was conducted

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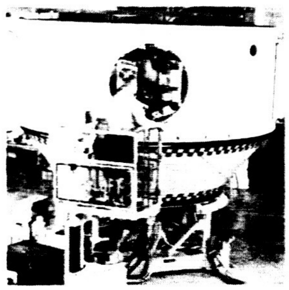

132. SA-5 Instrument unit
133. SA-4 launch

133

for a planned period of 143 seconds. Subsequent analysis revealed propulsion system irregularities, and a third static firing was conducted on March 27 to confirm corrections. This test, successfully conducted for a duration of 144 seconds, concluded S-I-5 flight qualification testing.[100]

NASA Headquarters approved MSFC procurement plan for four additional S-IVB stages on March 22.[101] On the same day, at MSFC, checkout of the SA-5 instrument unit was begun.

Saturn SA-4, the fourth and last of the single-powered-stage, Block I vehicles, was successfully launched on March 28 from Launch Complex 34. The vehicle, carrying several Block II components for test, reached an altitude of 80 statute miles. Range was 218 statute miles and peak velocity 3660 miles per hour. As a secondary mission the No. 5 inboard engine was cut off at 100 seconds to test the vehicle engine-out capability. Overall performance of the flight was very satisfactory.[102]

As the Saturn I project entered its final phase, work on the larger Saturns proceeded. On March 12 Douglas, S-IVB stage contractor, invited bids for a construction contract for the Beta Complex at SACTO; the contract was awarded in late March.[103] Also in March S&ID placed a contract for the S-II battleship tank structure; fabrication of components began early in April. The first S-IC cylindrical skin segment was completed by Boeing at Wichita during April.

The S-I-D5 stage was removed from the Dynamics Test Tower at MSFC on March 18. The booster was shipped to Cape Canaveral on April 5 for use in facilities checkout of Launch Complex 37B. The stage arrived at the Cape on April 15 and was erected three days later. On April 19 the S-IV Dynamics/Facilities vehicle was erected. Calibration and mechanical checks were begun the week of April 24, followed by propellant loading tests early in May.

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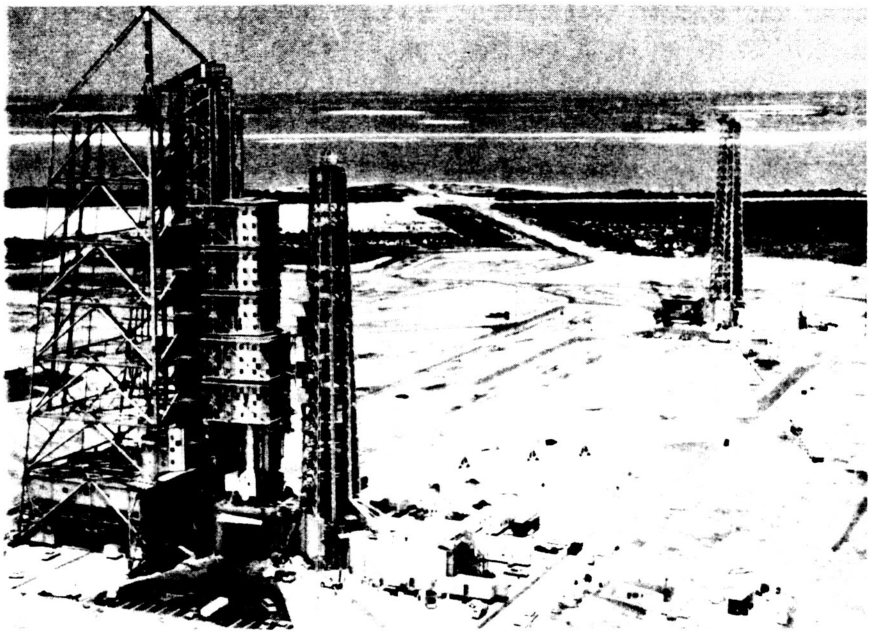

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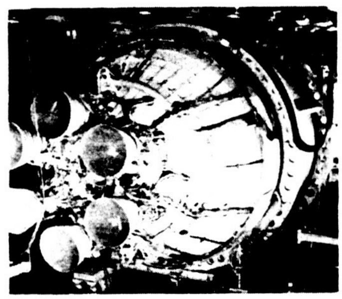

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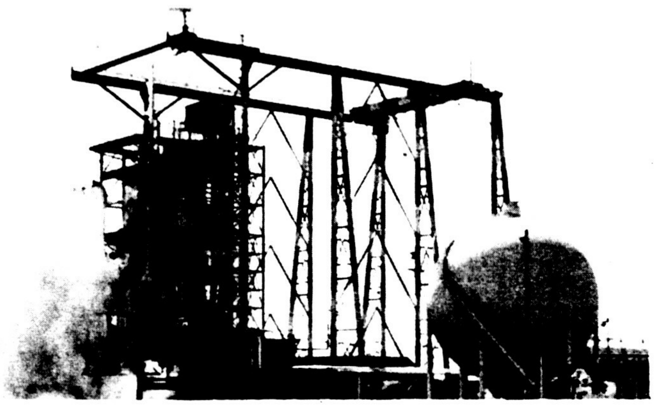

134. Facility checkout of Launch Complex 37B
135. Checkout of S-IV-5
136. Completion of S-IV battleship test program

During early April Douglas finished checkout of S-IV-5 at Santa Monica. On April 19 the stage arrived at SACTO and was installed on Test Stand 2B on May 22. Static testing followed modifications and engineering changes.[104]

On April 22 MSFC installed S-I-6 in its static test tower. The first short-duration static firing was successfully conducted on May 15 for a duration

2

of 33.75 seconds.[105]

Douglas initiated S-IV all-systems propellant loading tests at SACTO on April 1. Tank bending and insulation cracking halted testing for field repair of the tank. On May 14 another test was performed and a hydrogen leak was detected in the common bulkhead. The vehicle was removed from Test Stand 2B for inspection repair on May 18.[106]

At SACTO Douglas completed the S-IV battleship test program with a final LOX depletion firing of 444 seconds on May 4. Sixteen tests totaling 4302.5 seconds were accomplished using the RL10-A-3 engines. The complete battleship test program (including both A-1 and A-3 engines) had a total firing time of 5440.1 seconds. On May 13 a one-engine gimbal test was conducted. On May 21 the battleship tank was shipped from SACTO to MSFC. It was used by the Center for liquid hydrogen slosh test. Five of the six engines were shipped to MSFC and used on the dynamic vehicle for gimballing tests.[107]

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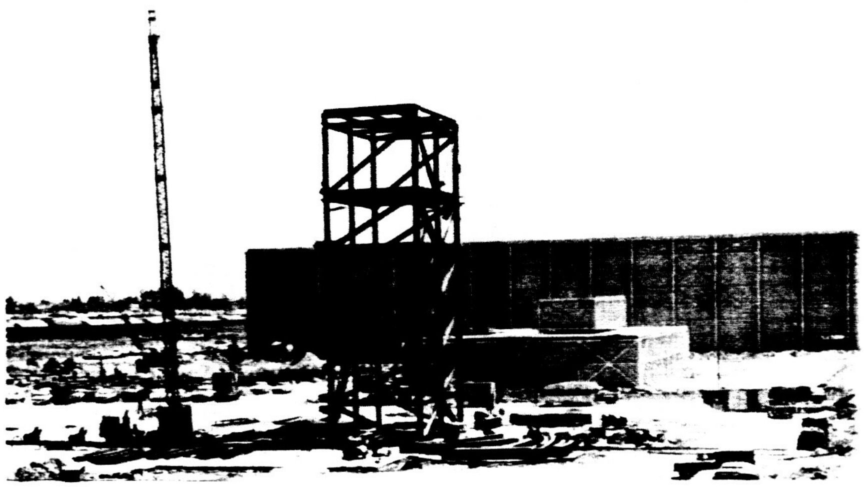


137. Douglas Huntington Beach Facility

138. S-IVB forward mockup

138

During May the S-IVB Huntington Beach fabrication and assembly building was completed and construction of the assembly tower begun. Also during May MSFC received the S-IVB forward area mockup from Douglas to be used to determine interface requirements between the S-IVB and instrument unit.

On May 18 at Michoud Chrysler finished clustering of propellant containers for S-I-8, the first booster fabricated by industry rather than by federal personnel at MSFC.[108]

During early May the J-2 engine, used on S-IVB and S-II stages, was successfully fired for the first time at a simulated space altitude in excess of 60,000 feet. The engine developed 200,000 pounds thrust; after 20 seconds the test was terminated as programmed.[109]

On May 13 NASA negotiated a firm cost proposal for incorporation of dual plane separation for S-IC/S-II stages with S&ID.[110] During mid-May land clearing at Mississippi Test Operations began in preparation for the dredging of a barge harbor and access channel; a 10.5-mile track of railroad was completed into the test site.

Dynamic testing of the S-IV stage, instrument unit, and Jupiter-type payload was completed at MSFC during mid-May. On May 23 the Apollo boilerplate and associated units were installed and testing resumed; this phase of testing was completed on June 16. Also during May MSFC engineers completed the design of the S-IC stage transporter.

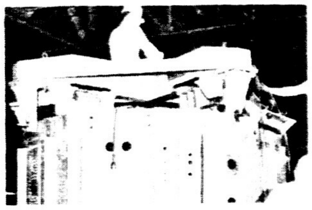
On May 28 MSFC awarded a contract for Federal Aviation Agency (FAA) certification flights of a modified B-377 aircraft. The aircraft would be used for transportation of the S-IV stage and other cargoes. Formal FAA certification was received on July 10.[111]

During the first of June MSFC personnel began occupancy of the new Central Laboratory and Office

139. Fabrication and assembly of S-I-8 at Michoud; a. barrel assembly, b. lower thrust ring, c. tail unit, d. thrust structure, e. spider beam, f. LOX and fuel tanks ready for clustering, g. installation of center LOX tank, h. clustering 70-inch LOX tanks, i. clustering 70-inch fuel tanks, j. final assembly

140. Pregnant Guppy aircraft

139 a.



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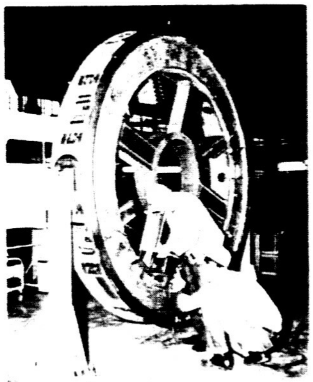

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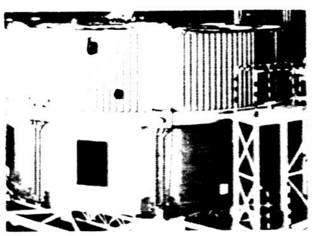

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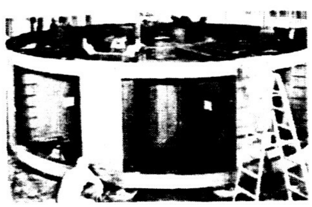

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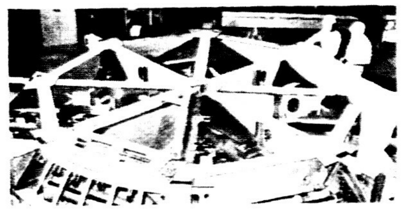

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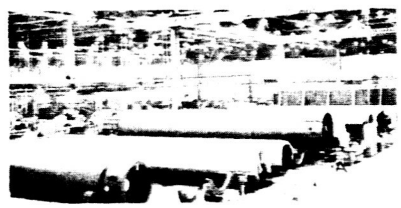

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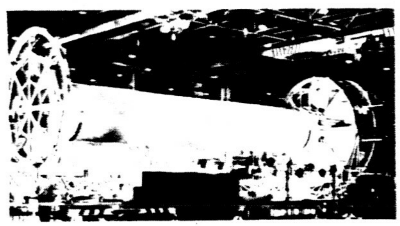

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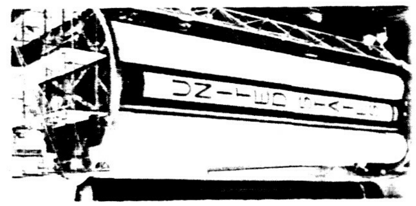

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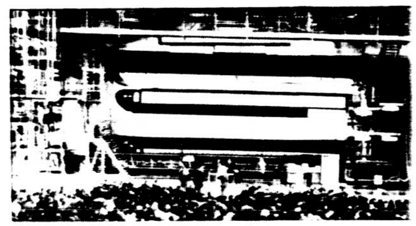

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Building. Also at MSFC construction of the Saturn V Dynamic Test Tower foundation began in early June. A full-duration, S-I-6 flight qualification static test was successfully conducted on June 6 for 142.37 seconds. The inboard engines were cut off by LOX low-level sensors at 136 seconds and the outboard engines six seconds later. On June 17 the stage was removed from the stand for post-static checkout.[112]

On June 5 limited beneficial occupancy was granted

on the S-IC stage Vertical Assembly and Hydrostatic Test Facility at MSFC.[113] Clustering of tanks for S-I-9, the last Saturn I booster to be fabricated at MSFC, began on June 4 and was completed on June 19; inboard engine installation was completed on July 17.[114]

On June 17 the Corps of Engineers awarded contracts for excavation for lock and bascule bridge, emergency service building, dredging of East Pearl River and clearing of Saturn V complex at

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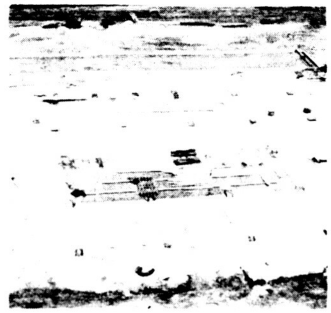

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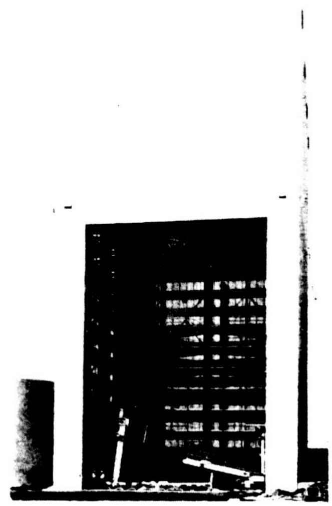

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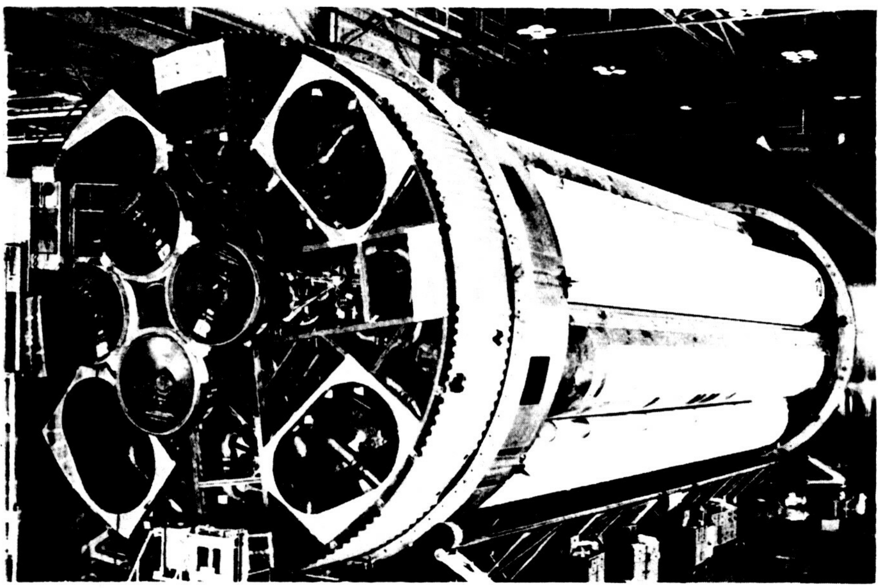

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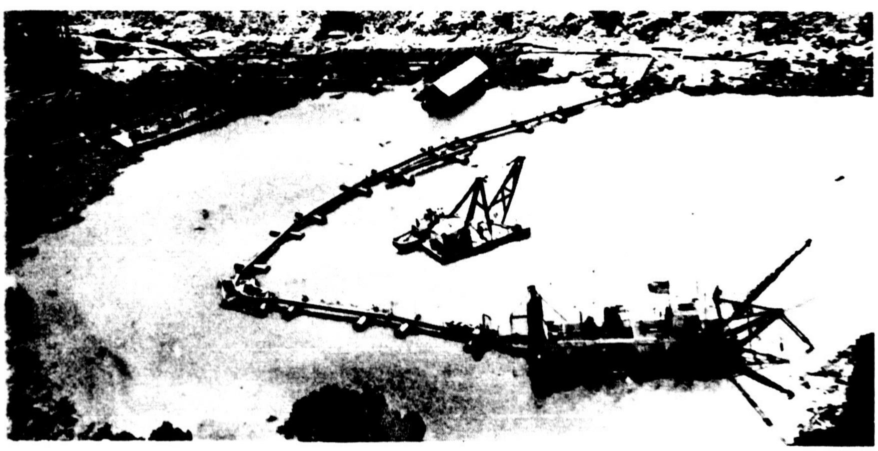


141. Saturn V Dynamic tower
142. S-IC facility
143. Assembly of S-I-9 stage
144. Dredging at Mississippi Test Facility

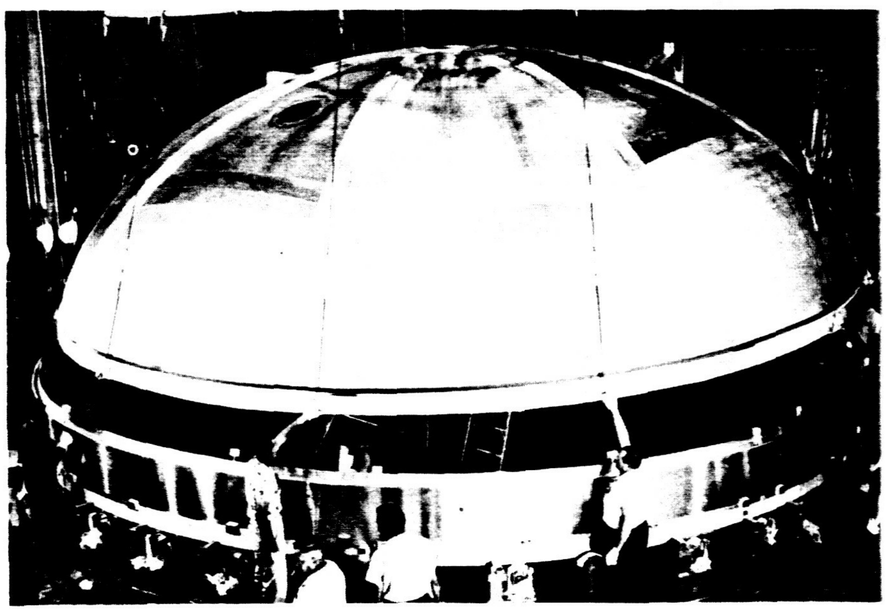
the Mississippi Test Operations. At MSFC gimballing tests on engine No. 1 of the S-IV stage were completed in pitch and yaw directions on June 28. Three days later dynamic tests of the S-IV stage with Apollo boilerplate and launch escape system were completed.

Pre-static checkout of the S-IV-5 stage at SACTO began on June 18.[115] During late June repair of the all-systems common bulkhead was completed. On July 6 the vehicle was installed on Test Stand 1 at SACTO. At Santa Monica, Douglas completed checkout of the S-IV-6 stage on July 19.[116]

During June MSFC welded the upper bulkhead for the S-IC test fuel tank to the Y-ring. Also during

145. Mating bulkhead to Y-ring

145



June facility checkout of Launch Complex 37 Pad B was completed at Cape Canaveral. The S-IV Dynamics/Facilities vehicle was flown to the West Coast for flight performance test of the Pregnant Guppy aircraft.

The S-I-D5 stage departed Cape Canaveral on July 1 aboard the barge Palaemon, arriving at MSFC

on July 14; the stage was used for additional dynamic testing. On July 9 MSFC directed Chrysler to proceed with fin redesign as part of the S-IB stage redesign effort.[117]

On July 25 the Corps of Engineers awarded a contract for construction of S-IC and S-II stage test stand foundations at Mississippi Test Operations. At MSFC during late July the concrete towers for the S-IC Static Test Stand were completed and steel erection begun. The Center successfully welded the S-IC upper cylindrical skin section to the Y-ring.

During July construction of foundations was completed for Test Stand 1 and 3 at SACTO Beta Complex. Also at SACTO, Douglas initiated hydrostatic test and calibration of the S-IVB battleship tank on August 2.

On August 5 NASA completed S-IB contract negotiations with Chrysler Corporation at Michoud.[118]

146. S-IB stage
147. S-IC static test tower

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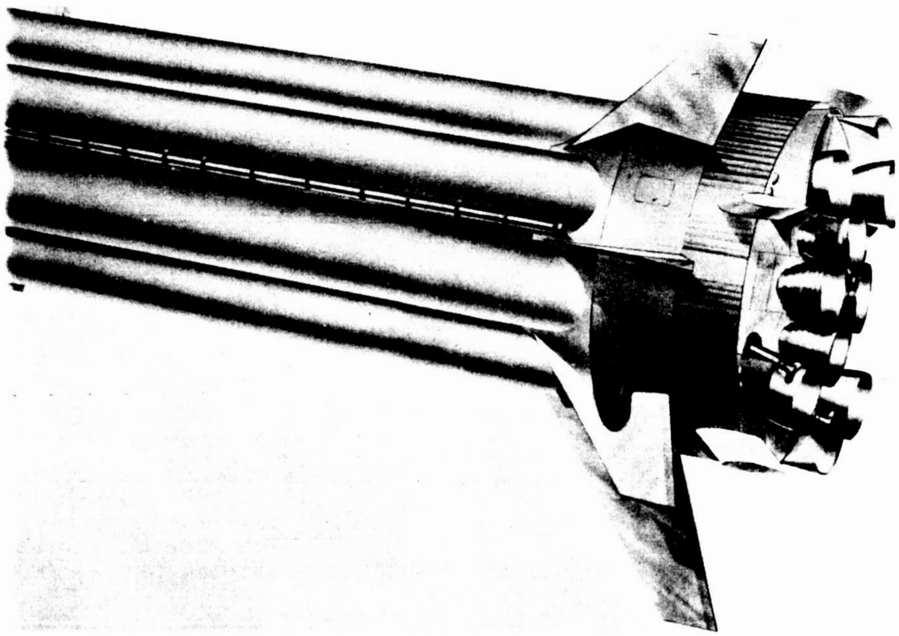

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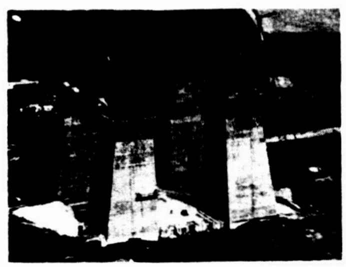

The following day S-IVB/Saturn IB contract negotiations were completed with Douglas Aircraft Corporation at Santa Monica.

On August 6 the Corps of Engineers awarded a construction contract for the Mississippi Test Operations Laboratory and Engineering Building. During August hydraulic dredging and fill operations were completed for the vertical assembly building at Cape Canaveral. MSFC awarded a contract on August 6 for assembly of two S-IC transporters; assembly began two days later.

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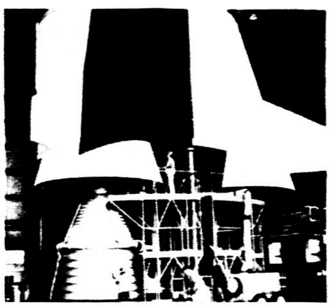

148. Construction at Launch Complex 39
149. S-IC stage aft area mockup

On August 11 MSFC started the S-I-5, S-IU-5, and Payload toward Cape Canaveral.[119] MSFC installed on the barge Promise a complete dynamics test vehicle of the SA-6 configuration in the dynamic test tower.[120]

Also at MSFC during early August the S-IC aft area mockup was completed, with two F-1 engine mockups attached.[121]

On August 5 the first attempt to acceptance fire the S-IV-5 stage at SACTO was aborted at 63.6 seconds due to an indication of fire in the engine area; however, inspection revealed an instrumentation malfunction in ground support equipment. On August 12 a successful 477-second, full-duration S-IV-5 flight qualification firing was conducted.[122] During August the S-I-5 stage, booster

for the fifth Saturn flight vehicle, was erected at Cape Canaveral.

On September 1 Dr. Wernher von Braun, MSFC Director, announced a major reorganization of the Center. Progress in the Saturn program, and a rise in industrial participation to approximately 90 percent of the budget, necessitated the changes. The Center created two major subdivisions — Research and Development Operations and Industrial Operations. Research and Development Operations, composed of the nine technical divisions redesignated laboratories, was strengthened for its Huntsville-based operations and for specialized contractor assistance. Industrial Operations was created to direct the portion of the Center's work performed by prime contractors, mainly the development of stages and engines for the Saturn I, Saturn IB, and Saturn V multi-stage rockets.[123]

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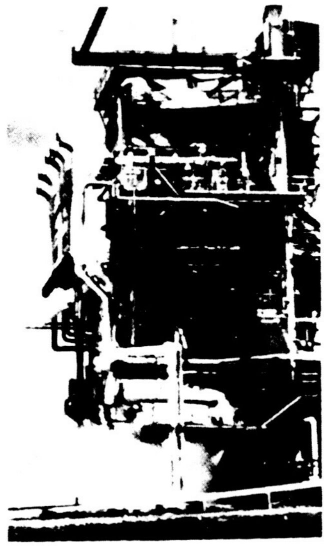

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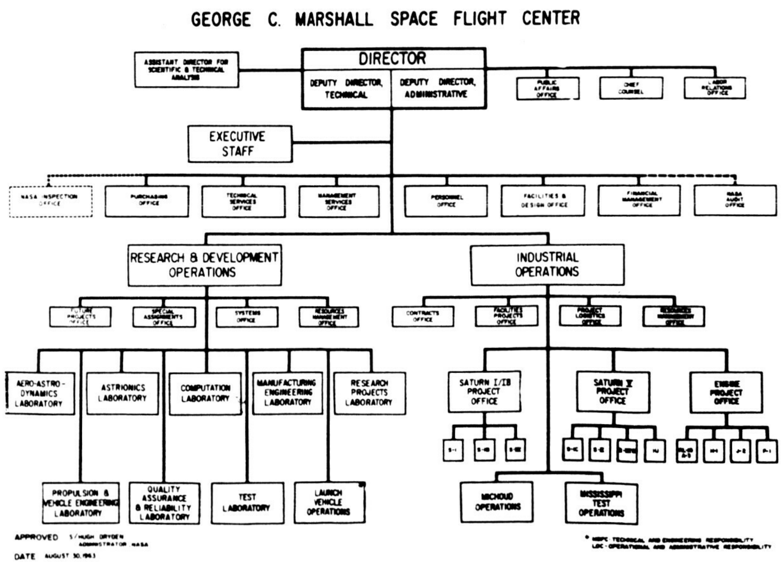

150. S-IV-5 acceptance firing
151. MSFC reorganization

In mid-September Douglas flew the S-IV-5 from SACTO to the Cape via the Pregnant Guppy aircraft.[124] Other Saturn I progress in September included MSFC's final assembly of the S-I-9 and Douglas' beginning of pre-static checkout of the S-IV-6 stage.

The Saturn IB second stage contract modification was signed by Douglas and submitted to NASA on September 10. In the same month a joint MSFC/ Manned Spacecraft Center Ad Hoc safety meeting considered Saturn IB crew safety and developed a "Preliminary Emergency Detection System" specification. Douglas began installing insulation on the S-IVB battleship stage, a heavier version for ground tests of the S-IVB flight stage.[125]

During September MSFC completed Saturn V's S-IC forward area mockup and completed the S-IC-T (all systems) intertank assembly.[126] Numerous research activities were under way: MSFC's Test Laboratory studied sound suppression problems, Jet Propulsion Laboratory (JPL) and Lewis Research Center began S-IC base heat-

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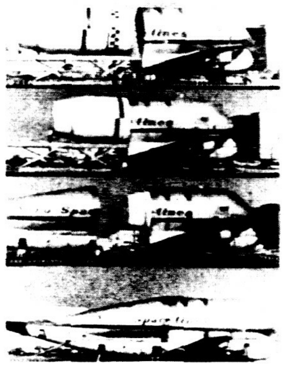

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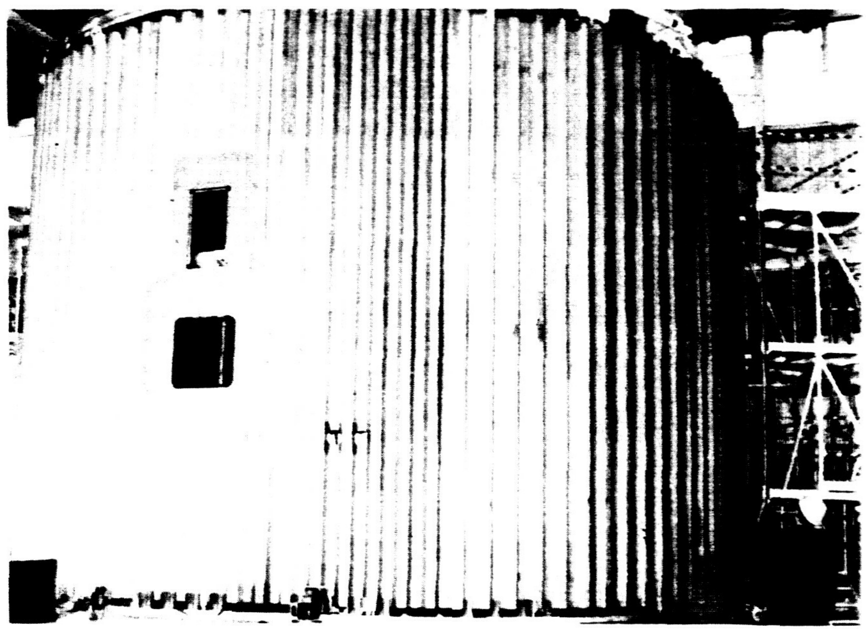

152. Loading of S-IV stage
153. Intertank for S-IC-T

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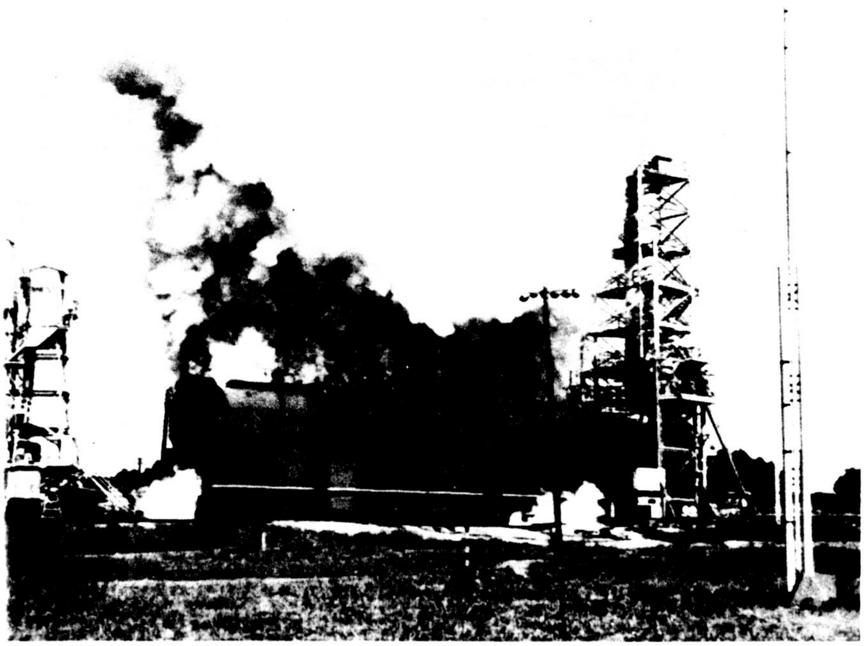


ing tests. The contractor for the Saturn V second stage, S&ID of North American Aviation, began PERT reporting at Seal Beach on the S-II program with eleven networks reflecting about 8500 activities. On September 23 S&ID sent MSFC the S-II and forward interface mating mockups for use in mating tests of the S-IC forward skirt.[127]

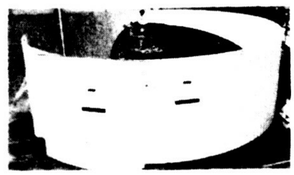
In October technicians at Launch Complex 37B joined the S-IV-5 stage, payload, and instrument unit to the S-I stage. Pre-launch checkout of the SA-5 vehicle continued.[128] In Huntsville MSFC completed the SA-5 flight operational sequence plan, providing for nine-hour completion of launch day tasks.

Progress on the other Saturn I vehicles continued during October. Chrysler completed assembly of the S-I-8 stage at Michoud.[129] MSFC personnel discovered and corrected minor problems in the in-

154. Experimental firing in sound suppressor development program

155. S-II stage activities; a. S-II aft interstage mockup, b. S-II forward interstate mockup, c. S-II bulkhead fabrication building at Seal Beach, d. S-II structural test tower at Seal Beach, e. bulkhead fabrication area at Seal Beach, f. gore forming facility at El Toro, g. S-II skate bulkhead welders at Seal Beach, h. Explosive forming die at El Toro

155 a.



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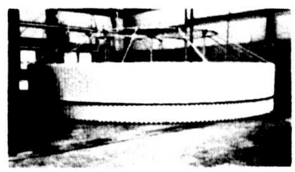

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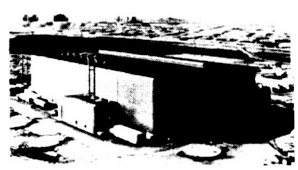

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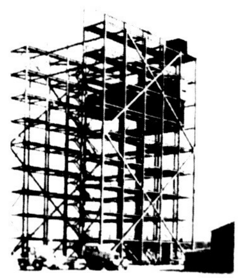

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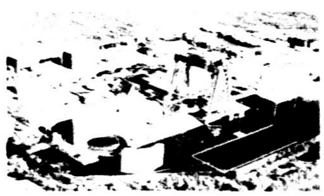

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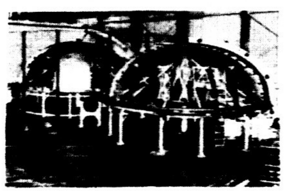

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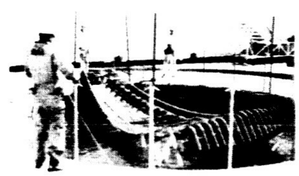

strument unit network of the SA-6 vehicle.[130] The Center's Test Laboratory static tested the SA-7 booster for the first time, and on October 22 performed the second and final acceptance test on S-I-7 for a duration of 138.93 seconds.[131] The Douglas second stage work at SACTO included initiation of pre-static checkout of the S-IV-6 and start of assembly of the S-IV-10.

NASA approved a Chrysler contract modification in October that provided for 12 Saturn IB boosters in lieu of operational Saturn I boosters. At Michoud, Chrysler continued design studies on components for these S-IB stages. MSFC approved the design release for the S-IB spider beam and completed the 50 percent design review of the gaseous oxygen line and diffuser. Douglas continued work on hydrostatic and dynamic test equipment for Saturn IB's second stage and began assembly of its S-IVB battleship stage at SACTO. Douglas began fabricating an S-IVB liquid hydrogen test tank in Huntsville for use in J-2 engine tests.

Boeing personnel at Michoud completed the Saturn V booster lower thrust ring assembly in October.[132] MSFC personnel continued fabrication of the fuel tank and other major components for the S-IC test stage. S&ID continued fabrication and assembly of ground test S-II stages and construction of test stands. On October 31 MSFC received from Rocketdyne Division of North American Aviation the first production model of the huge F-1 engine.[133]

NASA announced on October 30 a rephasing of Saturn manned flight missions. Saturn I manned missions were dropped and six Saturn I vehicles thereby deleted. The Saturn I program will terminate with completion of the ten unmanned flight vehicle research and development program. NASA approved speed-up of Saturn IB development. The more powerful Saturn IB vehicle will launch the Project Apollo manned flights in preparation for Saturn V's manned moon mission. "All-up" testing will be utilized in future Saturn flights. That

is, there will be no further flights with dummy stages; development flights will test Saturn vehicles in final configuration.[134]

In November NASA postponed the fifth Saturn I flight because of technical problems with the SA-5 vehicle.[135] At SACTO Douglas placed the SA-6 vehicle's second stage in a test stand. On November 22 Douglas conducted a successful 460-second acceptance firing of this S-IV-6 stage.[136] During November Douglas finished assembly of another Saturn I second stage, the S-IV-7. The first Chrysler-built booster, S-I-8, was in final checkout.

MSFC and Chrysler completed their study of the use of uprated H-1 engines in Saturn IB's booster

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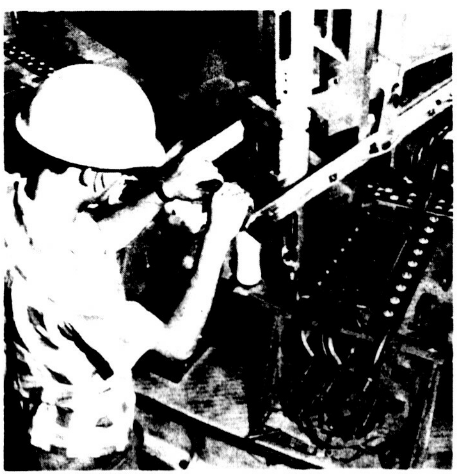

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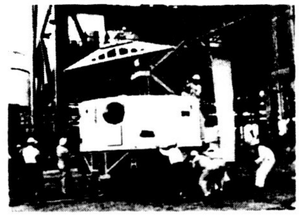

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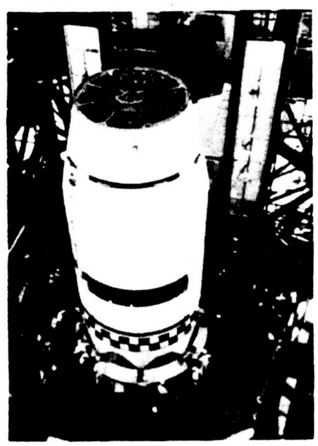

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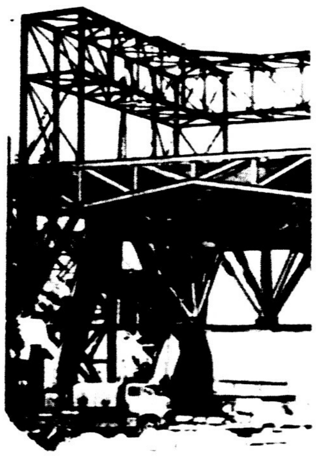
156. Erection of SA-5 at Cape Canaveral, a. instrument unit, b. S-IV-5 stage, c. hoisting instrument unit, d. payload adapter, e. hoisting payload, f. payload, g. SA-5 at Launch Complex 37B
157. S-IVB liquid hydrogen test tank, MSFC

d.



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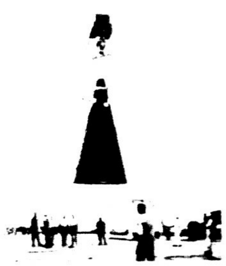

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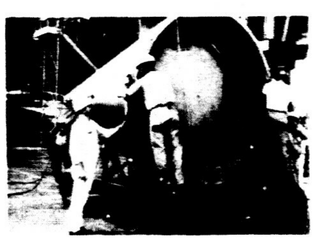

158. Michoud mechanic drilling holes in the first S-IC lower thrust ring

159. S-II test stand construction at Santa Susana; a. flame deflector in battleship test stand, b. all-systems test stand, c. battleship test stand

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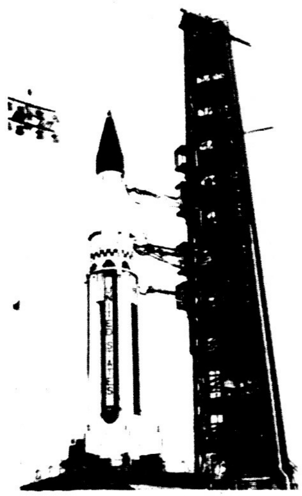

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stage. On November 8, after Chrysler determined engine load criteria and Saturn IB schedule impact, MSFC directed Rocketdyne to develop the more powerful engine.[137] Douglas occupied its joint Engineering Development Systems Integration Laboratory/ Systems Integrations Area facility on November 1. Second stages for Saturn IB (S-IVB) will be assembled and tested in this Huntington Beach facility. At Michoud during the month Chrysler completed a mockup of the S-IB spider beam and began manufacturing the second stage adapter.[138]

NASA contracted on November 12 for a Saturn V launch pad at Kennedy Space Center, Complex 39.[139] The pad will cost over $19 million. MSFC continued manufacture of Saturn V booster test stage components in November. The Center began S-IC stage test fuel tank assembly in its new Vertical Assembly Building. Additions to the Saturn V booster contract increased Boeing support to MSFC and raised the total value of the S-IC contract to more than $447 million. On November 8 MSFC contracted for a $13.4 million test complex at Mississippi Test Operations for the Saturn V

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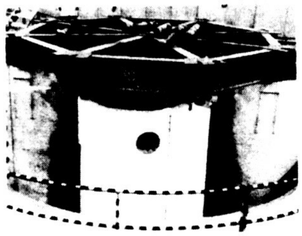
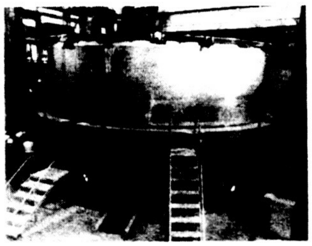


160. Second stage for SA-6 flight being placed in SACTO stand for acceptance testing
161. Spider beam mockup for Saturn IB'S first, S-IB, Stage

162 a.



162. Saturn V booster test stage components: a. assembly of S-IC test fuel tank, b. welding S-IC bulkhead

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164

163. Assembly of S-II battleship
164. First J-2 extended-duration firing test

second stage (S-II). At Seal Beach, S&ID continued assembly of the S-II battleship stage for static tests.

An important engine development milestone occurred on November 27 with Rocketdyne's first extended-duration firing test of the J-2 engine. This successful test of the 200,000-pound thrust, liquid hydrogen-fueled engine lasted for more than 8 minutes. The J-2 will power upper stages of both the Saturn IB and the Saturn V vehicles.[140]

On November 28 the name of the NASA facility at Cape Canaveral was changed officially to John F. Kennedy Space Center (KSC).

MSFC in December postponed the SA-5 flight until January 1964 after discovering cracks in fuel line fittings on the S-I-5 stage. MSFC decided to replace critical tubing on it and all remaining S-I stages. On December 13 MSFC accepted from Chrysler at Michoud the first industry-built Saturn I booster (S-I-8).

By the end of December Chrysler had completed and MSFC had approved most of the structural redesign of Saturn IB's first stage.[141] During the month NASA awarded the basic S-IVB contract modification which also accelerated the program for this Saturn IB second stage.[142] Also, Douglas completed fabrication of major components for the S-IVB hydrostatic test stage.[143]

Saturn V progress during the month included MSFC's first F-1 engine tests on December 3 and 5. Duration of the first firing tests was 1.25 seconds. The second firing lasted 10 seconds.[144] On December 20 NASA updated the Boeing S-IC contract to amend the stage delivery schedule.[145] The contract as changed meant that MSFC rather than Boeing would provide the second S-IC flight booster. On December 27 NASA amended the prime S-II stage contract with S&ID in order to make the first S-II flight stage "live" instead of

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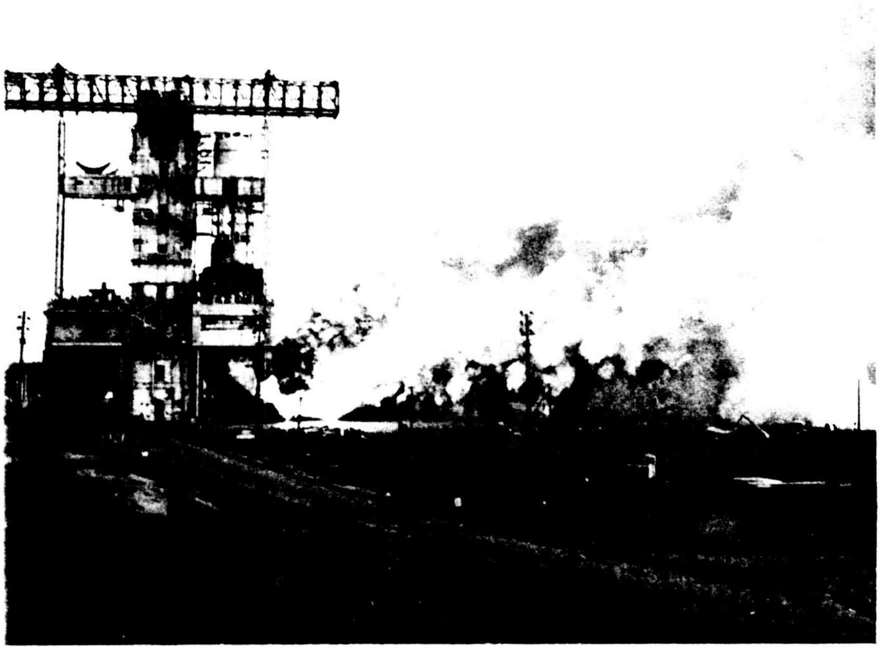


165. *MSFC F-1 engine firing test*

dummy.[146] During December NASA signed an agreement with the Military Sea Transport Service (MSTS); by the agreement the USNS Point Barrow would be used for shipment of S-II stages from the West Coast manufacturing site to test and launch sites.[147]

January 1964 saw the beginning of the last phase of the Saturn I research and development program. The first four flight vehicles had carried dummy second stages. Now flight testing of second stages began.

Early in January technicians installed new tubing assemblies in the SA-5 booster. On January 24 Douglas second stage work under way at SACTO suffered a setback when the S-IV all-systems vehicle exploded during an attempt to static fire it.[148] An overpressurized oxidizer tank caused loss of this vehicle as well as damage to the test stand

and ground support equipment. On January 27 a blocked fuel line caused a two-day postponement of the SA-5 flight; technicians had failed to remove a flange used in checking the LOX line.[149]

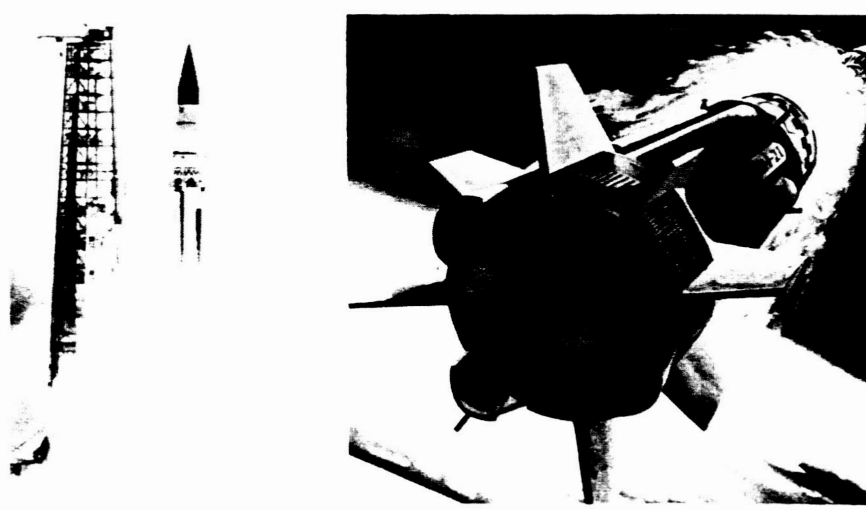
On January 29, 1964, NASA launched the fifth Saturn I. The liquid hydrogen-fueled second stage, flight tested for the first time, functioned perfectly. First-stage engines shut off as planned, 147 seconds after liftoff. The second stage separated, ignited, burned for 8 minutes, and with the attached instrument unit and sand-filled nosecone attained orbit as an earth satellite. Time from liftoff until orbit was 10.32 minutes. The almost 19-ton satellite was the heaviest ever orbited.[150]

Meanwhile, MSFC continued production of test components and expansion of test facilities for Saturn IB and Saturn V multi-stage rockets. NASA announced in January that construction budgets for Saturn IB and Saturn V facilities at Michoud and the nearby Mississippi Test Operations would be $6,534,000 and $61,991,000, respectively, for FY 65.

In February MSFC shipped Saturn I's sixth flight booster and instrument unit from Huntsville to

166. a. Fifth Saturn I flight
b. second stage separation

166 a. b.



KSC; the trip by barge took eleven days.[151] Douglas flew the S-IV-6 stage to the Cape. On February 19 MSFC successfully completed meteoroid payload fairing separation tests for SA-8 and SA-9 missions. MSFC decided that the sixth Saturn I vehicle would have an active guidance system.

In February, Chrysler started fabrication of components for the first two Saturn IB boosters, utilizing some of the components available from cancelled Saturn I vehicles. Second stage accomplishments included Douglas's fabrication work on the S-IVB/IB-1 as well as further development of the S-IVB hydrostatic, all-systems, dynamic, and battleship test stages. Douglas also worked on an S-IVB facilities checkout stage.[153]

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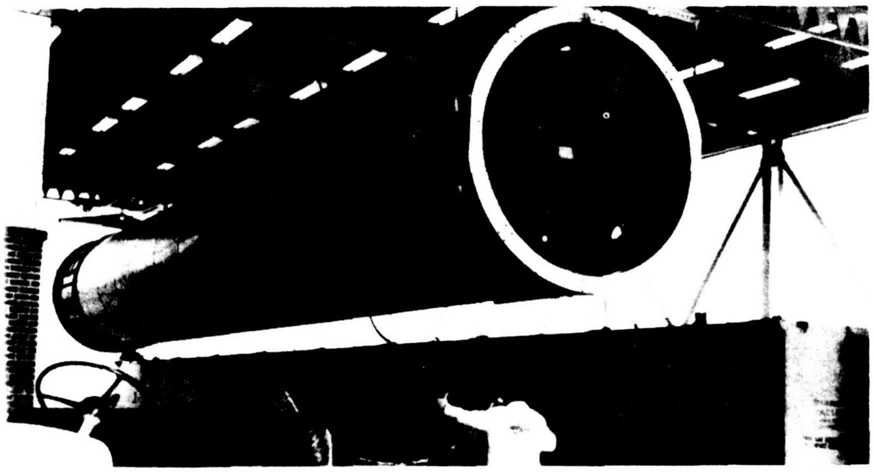

167. Saturn I LOX tank which will be modified for Saturn IB

Saturn V progress included MSFC's successful hydrostatic testing on February 8 of the first stage (S-IC) test fuel tank.[154] During February the Center conducted seven static tests on an F-1 engine.[155] At Edwards AFB an F-1 engine systems test on February 28 ended in an explosion and severe engine damage. Rocketdyne attributed the explosion to structural failure of the LOX pump.[156] Rocketdyne's other systems tests were generally successful. S&ID continued manufacture of the S-II battleship stage thrust structure and aft skirt assembly in its stand at Santa Susana.

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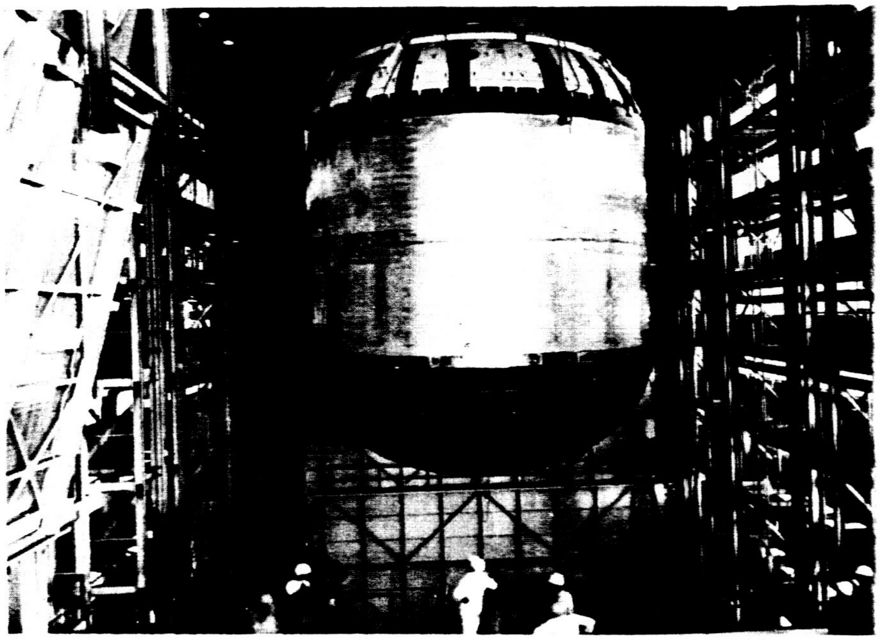

168. Saturn V test fuel tank

During February atmospheric physicists of MSFC's Aero-Astrodynamics Laboratory participated in a wind data study. In the ten-day search for atmospheric jet streams which affect rocket flight they released 161 weather balloons (rawinsondes). This was part of an extensive measuring program in the southeastern United States originated by MSFC to aid Saturn stage structural designers in studies on sound propagation.

In March Kennedy Space Center technicians worked overtime preparing for the sixth Saturn I launching. In Huntsville, MSFC performed vibration tests on the SA-9 instrument unit, S-IU-9, and also began dynamics testing on vehicles in the SA-8, SA-9, and SA-10 configurations. MSFC successfully static fired S-I-9, final booster manufactured by the Center, in a short duration test.[157] Douglas continued second stage production and started static tests on the S-IV-7 at SACTO.[158] Chrysler completed fabrication and replacement of critical tubing assemblies for S-I-10 at Michoud.

Saturn IB activities during March included begin-

ning of fabrication of components for the second S-IVB flight stage, the S-IVB/IB-2.[159] Douglas also started assembly of the S-IVB dynamics test stage in its assembly tower at Huntington Beach. Early in March the Center awarded a contract to IBM for Saturn IB and Saturn V instrument unit digital computers and data adapters.[160] MSFC also arranged for integrating the eight systems of the Saturn IB and Saturn V instrument units. These systems are: guidance, control, electrical, measuring, telemetry, radio frequency, structural, and environmental. International Business Machines (IBM), under a $5.5 million contract, will provide development plans, test plans, and procurement specifications during the five-year first phase of the contract.[161] On March 23 NASA published Saturn IB mission assignments as coordinated with MSFC and Manned Spacecraft Center.[162]

At Seal Beach, S&ID began assembly of the first Saturn V second stage (S-II) flight hardware. S&ID technicians conducted three successful tests of S-IC/S-II separation techniques. In Huntsville MSFC moved the completed S-IC test fuel tank to its load test facility on March 6.[163] Other MSFC Saturn V activities during the month included con-

169. Saturn I second stage production
170. S-IVB Dynamics Test Stage
171. MSFC static test stand for Saturn V booster
172. Joining Apollo to SA-6
173. S-I-8, first industry-produced Saturn booster, being unloaded from barge at MSFC

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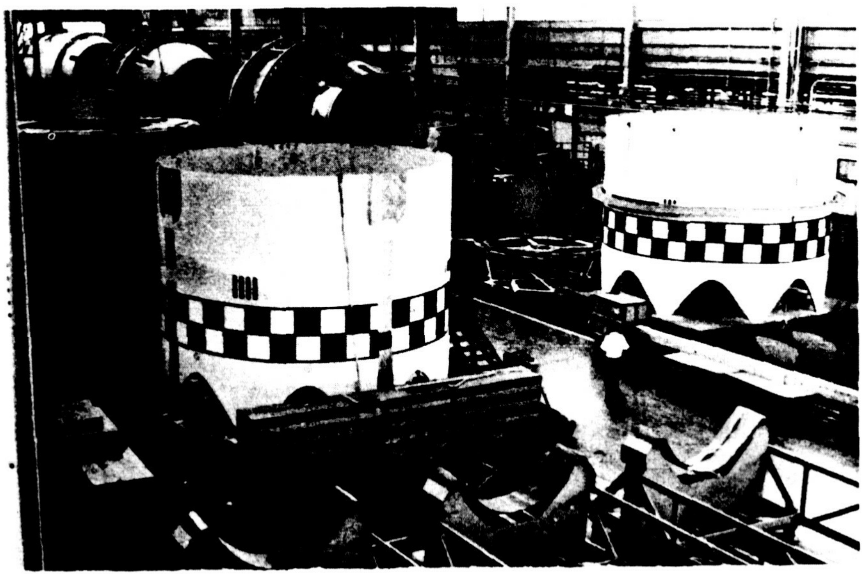

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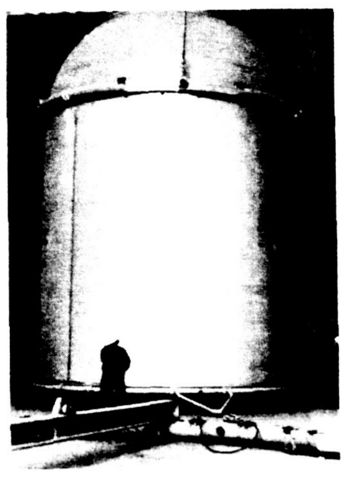

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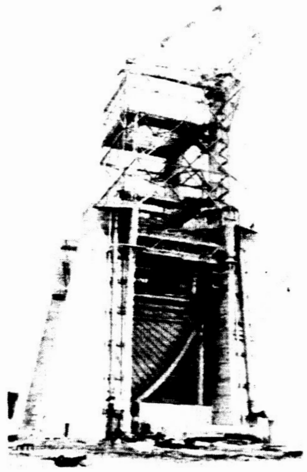

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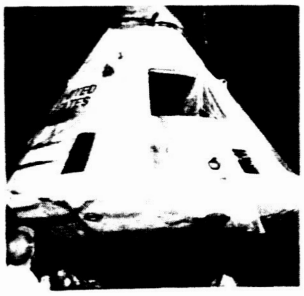

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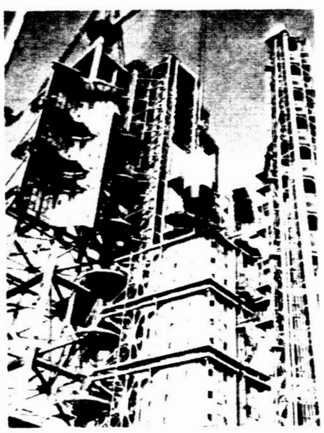

struction progress on the $30 million static test facility in the Center's West Test Area. This Saturn V static test facility will be used to test four S-IC stages in Huntsville: one flight booster built at Michoud by Boeing, a nonflight MSFC-built stage, and the first two S-IC flight stages, both to be built by MSFC. The Center completed the Dynamic Test Stand superstructure in March.[164]

NASA completed Saturn I second stage negotiations with Douglas Aircraft Corporation on April 17; scope changes increased the Douglas S-IV contract by $22 million. During April the Apollo command module was mated to the spacecraft. This Apollo payload was then joined to the SA-6 vehicle at Cape Kennedy.[165] On April 24 the first industry-produced Saturn I booster arrived at MSFC from Michoud. The Chrysler-built S-I-8 stage went directly to MSFC's static test stand. On April 29 Douglas successfully acceptance fired the S-IV-7 stage.[166] During April the Center decided to make minor changes in the S-IU-9 on the basis of vibration test results. MSFC announced that the SA-10 vehicle would carry a meteoroid detection satellite as its payload. This type payload, also to be used for the SA-8 and SA-9 flights,

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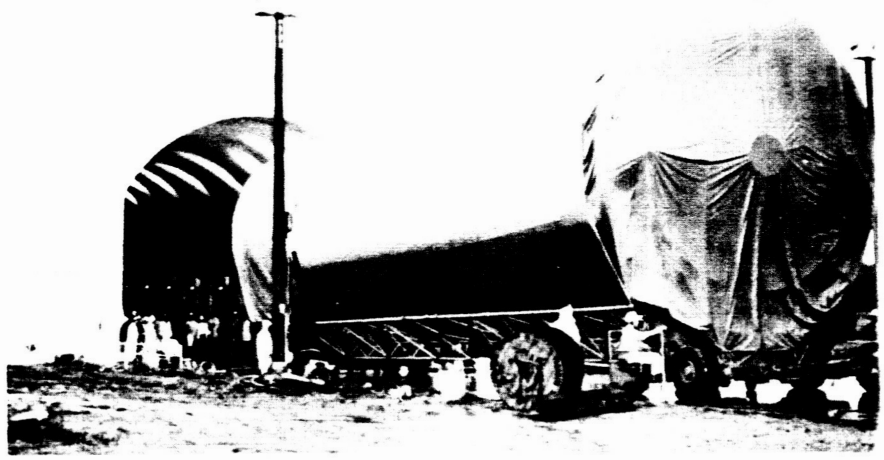

will aid the investigation of hazards from meteoroid particles to both manned and unmanned spacecraft.[167]

During a Saturn IB procurement discussion early in April, NASA and MSFC discussed the problem of orbital debris. NASA inquired about the possibility of controlled reentry of the S-IVB stage. Marshall feared a critical loss of load capability if the S-IVB were redesigned to provide this, but study of the problem continued. Early in April Douglas completed the S-IVB structural test stage at Huntington Beach. On April 14 the forward dome of the dynamics test stage for Saturn IB second stages was damaged during production proof testing of the propellant tank assembly. At Michoud during April, Chrysler progressed in the fabrication and assembly of the S-IB-1, the booster stage for SA-201, the first Saturn IB flight vehicle.[168] Chrysler technicians were putting together two major structural assemblies, the second stage adapter and the thrust structure, for the S-IB-1.

Early in April MSFC negotiated with Radio Corporation of America (RCA) for 19 ground computer systems to be used in checkout, static test, and launching of Saturn IB and Saturn V vehicles. Cost of these systems and seven ordered last year will total more than $47 million. They will be used at Michoud, Mississippi Test Operations, and Cape Kennedy Launch Complexes 34, 37, and 39.[169] NASA completed instrument unit arrangements for Saturn IB and Saturn V during April. Under a prime contract effective May 1, IBM became lead contractor for work which, together with previous instrument unit assignments to IBM, is expected to cost $175 million over a five-year period.[170] NASA delegated management of this work to MSFC. Meanwhile, Army engineers requested bids for an MSFC facility to study noise characteristics and sonic environment data independent of full-scale firings. Saturn IB and V upper stage engine production and testing continued at Rocketdyne's Canoga Park and Santa Susana sites. Rocketdyne delivered the first J-2 production

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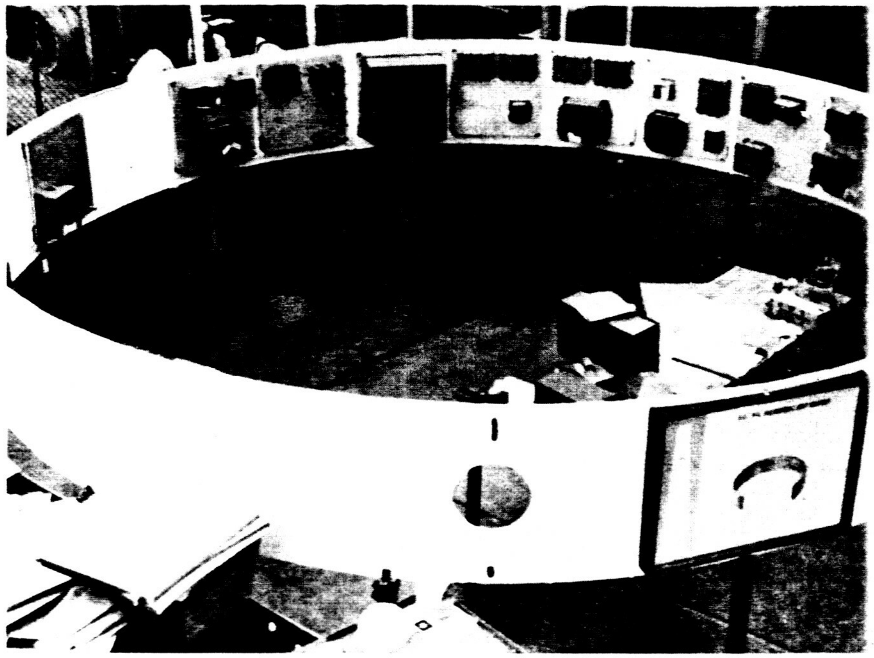

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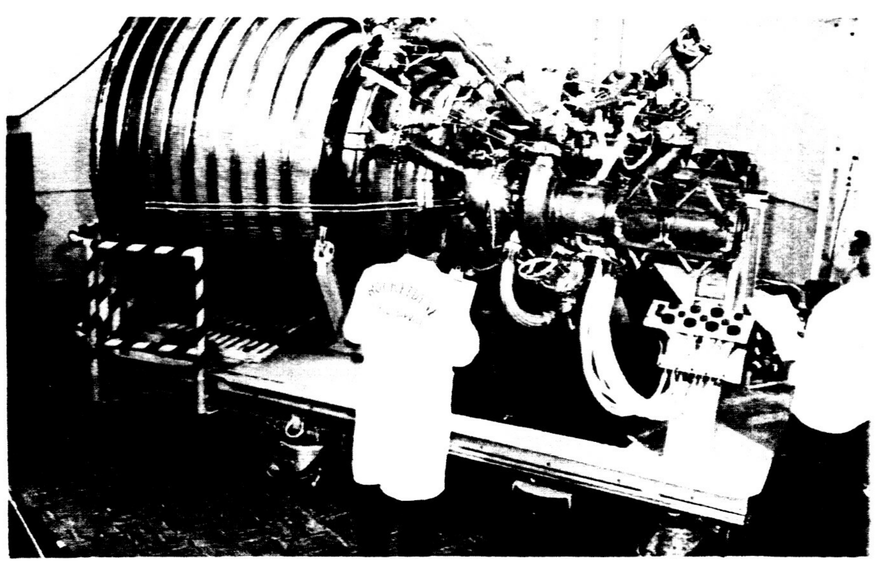


174. Mockup of instrument unit for Saturn IB and Saturn V

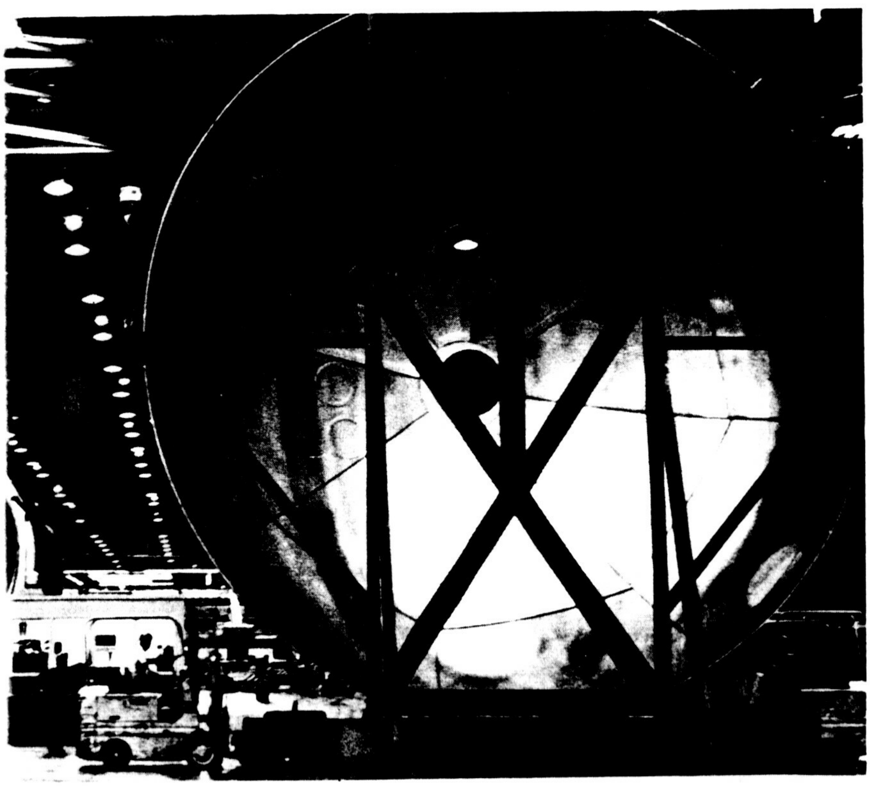
175. First J-2 production engine delivered to Douglas

engine to Douglas for the S-IVB battleship during April.[171]

Saturn V booster facilities in Huntsville continued to expand during April. MSFC awarded a con-

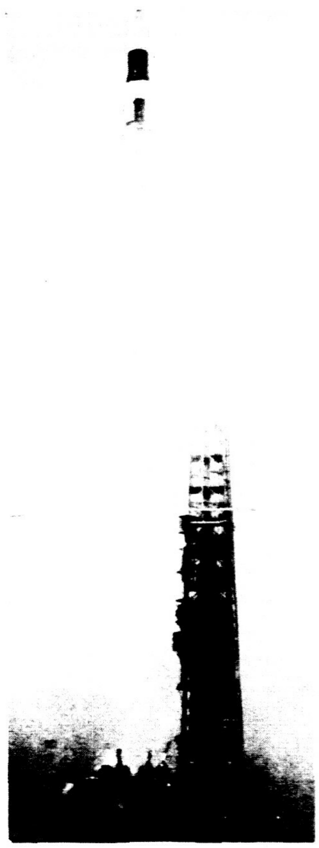
tract worth more than $2\frac{1}{2}$ million to Sullivan, Long, and Hagerty of Birmingham, Alabama, for a 100-foot-high hangar to house large components of this S-IC stage. NASA provided almost $6 million additional support for the S-IC booster program at Michoud in a contract supplement awarded the Boeing Company for additional research, quality assurance, and mission planning. At Downey, California, S&ID completed fabrication of two giant bulkheads for the Saturn V second stage (S-II). NASA also modified S&ID's contract in April, adding more than $12 million to provide for vertical checkout of the S-II stages at Seal Beach and at Mississippi Test Operations. The Center studied ground support equipment (GSE) needs for Saturn V. On April 22 MSFC held a conference on electrical support equipment (ESE) to be furnished by General Electric. MSFC personnel prepared a preliminary schedule of Saturn V GSE deliveries and installation.

176



176 Moving Saturn V booster tank bulkhead at Michoud

177 Early in May stress corrosion was discovered in aluminum tube assemblies in the S-IV-6 stage. These were replaced without delay to the SA-6 flight. However, minor problems in fueling the S-IV-6 stage caused a six-day launch delay and GSE compressor trouble held up the flight two days.[172]



177. Sixth Saturn I flight

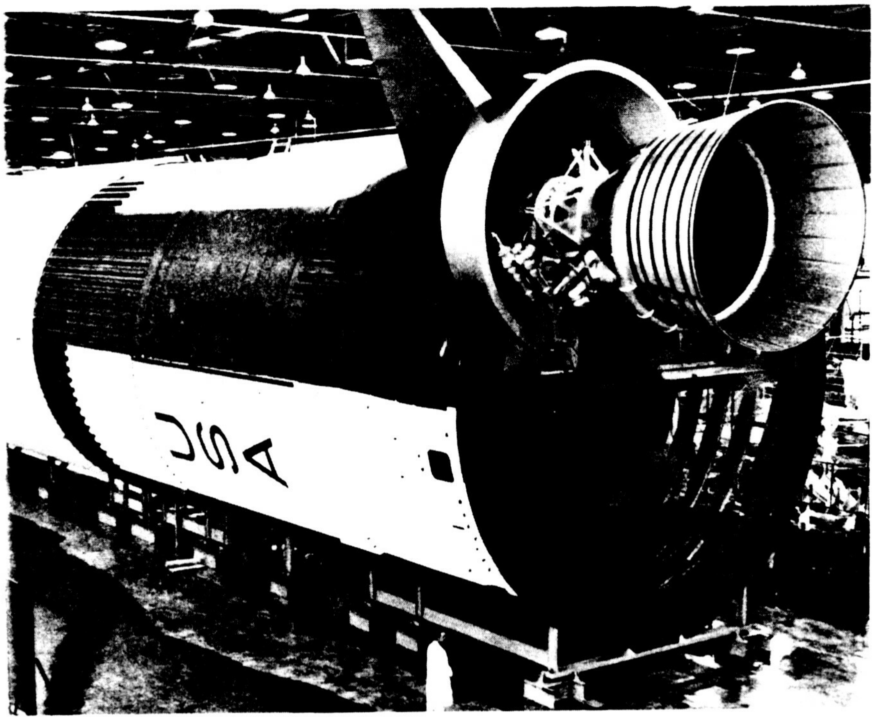
MSFC negotiated with Douglas on May 19 for Saturn IB ground support equipment and additional Saturn IB second stages. On May 27 MSFC and Douglas personnel agreed on a Douglas program of computer reporting for MSFC on S-IVB/IB status.

On May 4 Saturn V personnel met in Washington to consider the Apollo reliability and quality assurance program. During the month MSFC completed a plan for integrating computer information from Saturn V systems, stages, and projects. MSFC and Manned Spacecraft Center continued Saturn/Apollo interface study in meetings during May.

The sixth Saturn I flight occurred on May 28. The SA-6 flight was successful, as all preceding flights had been. The vehicle's guidance system, active in this flight for the first time, corrected a deviation from the planned trajectory caused by premature shutdown of one of the engines. The payload, 37,300 pounds and slightly lighter than that of the record SA-5 load, included a boilerplate Apollo spacecraft which reentered the atmosphere and disintegrated as expected after 3.3 days and 50 orbits of the earth.[173] On the day this flight took place, MSFC started the seventh flight booster and instrument unit on the water voyage to Cape Kennedy.

At the end of May 1964 four Saturn I flights remained. Fabrication of stages for the Saturn IB was under way. Saturn V, the launch vehicle for the Apollo mission, began to emerge. Ground test stages were taking form, and huge facilities that would test them were rising at MSFC,

178 a.

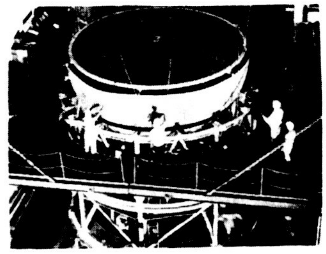


Michoud, Mississippi Test Operations, and contractors' sites.

During June MSFC, KSC, Manned Spacecraft Center, and associated contractors evaluated the sixth Saturn I flight. Included in their data were films from eight onboard movie cameras recovered after the flight and nearly 1200 performance measurements telemetered to ground stations during the flight. Analysis affirmed success of the onboard guidance system, severely tested by unexpected shutdown of one of the first stage engines. This ST-124 guidance system became active shortly after second stage ignition and corrected trajectory deviation. After the SA-6 review NASA decided to lighten the S-IV stage on the four remaining flights by reducing fuel reserve.[174]

Other Saturn I activity in June included arrival of SA-7 payload and vehicle major components at Cape Kennedy;[175] MSFC's successful ground firing

b.



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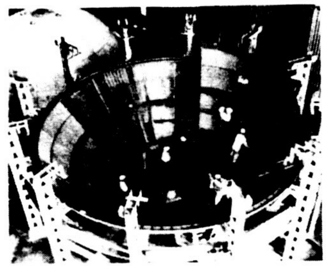

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178. Saturn IB and Saturn V progress at time of sixth Saturn I flight; a. LOX tank assembly for S-IVB stage, upper stage for Saturn IB and V, b. first Saturn V second stage, S-II, flight hardware, c. Saturn V booster full scale mockup at Michoud
179. On-board camera photograph of SA-6 stage separation

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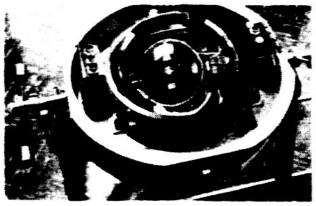

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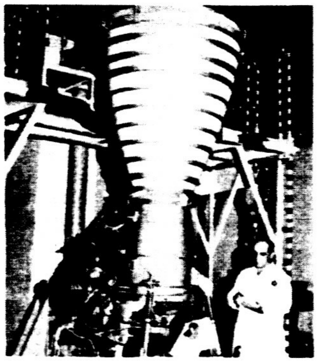

180. ST-124 guidance stable platform
181. H-1 engine, uprated for Saturn IB booster
182. Saturn IB second stages, S-IVB, in Douglas tooling tower, Huntington Beach

of S-I-8, the first booster produced by private industry; and start of assembly of S-IU-8, instrument unit for the SA-8 vehicle.[176]

NASA's middle-sized Saturn, Saturn IB, progressed during June to beginning of manufacture of the first flight booster. By mid-June North American Aviation-Rocketdyne had delivered the first four uprated 200,000-pound thrust H-1 engines to Michoud for the Saturn IB booster.[177]

Chrysler began clustering tanks of the first flight booster, S-IB-1, during June.[178] Douglas continued work at Huntington Beach on the Saturn IB second stages and progressed with assembly of a facilities checkout stage. Instrumentation problems delayed cold flow tests on the second stage propulsion test stage, the S-IVB battleship, but Douglas reported successful checkout of the S-IVB structural test stage before testing. A ground support equipment development highlight at Huntington Beach was successful checkout of second stage prototype automatic test equipment.

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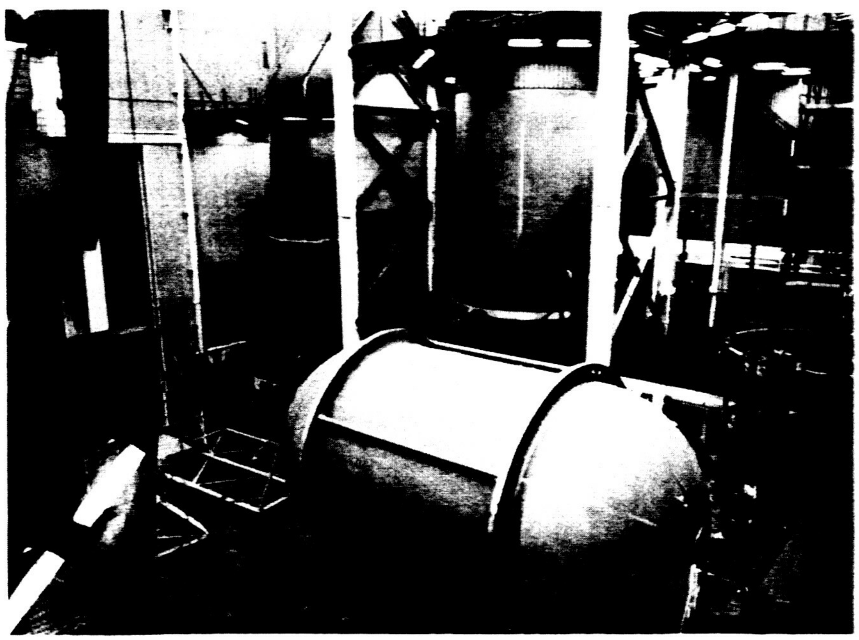

With Saturn V manufacture continuing, NASA announced during June that it would study the feasibility of increasing the weight-lifting capacity of the vehicle by more than one-third. MSFC sought proposals on which to base contracts for preliminary studies expected to cost about $2 million.[179]

In early July MSFC completed the last phase of the Saturn I dynamic test program with successful tests of the SA-8, 9, and 10 vehicle configuration. MSFC's Saturn I dynamic test stand would now be one of the complex of MSFC Saturn IB and Saturn V test stands.

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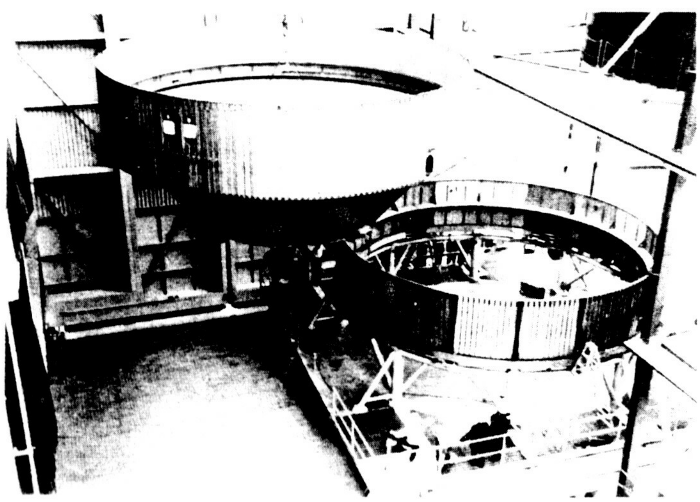

183. Fabrication of Saturn V; a. fuel and LOX tanks being built in Huntsville, for the Saturn V first stage, S-IC, b. structural test stage thrust unit at Seal Beach, for the Saturn V second stage, S-II

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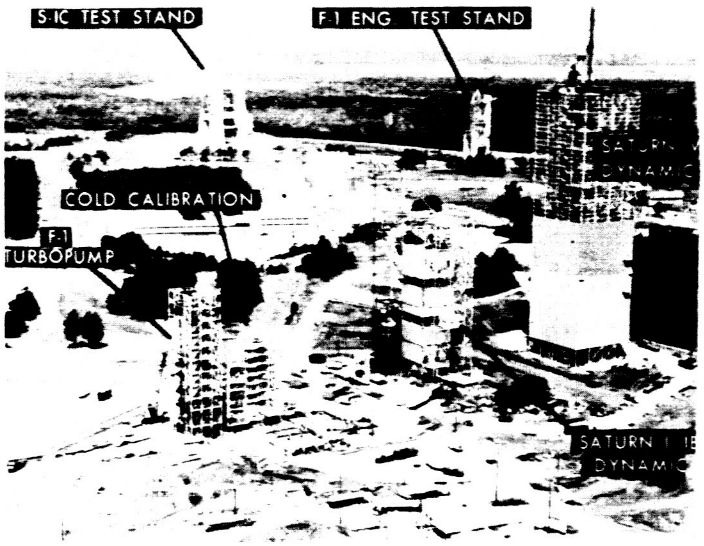

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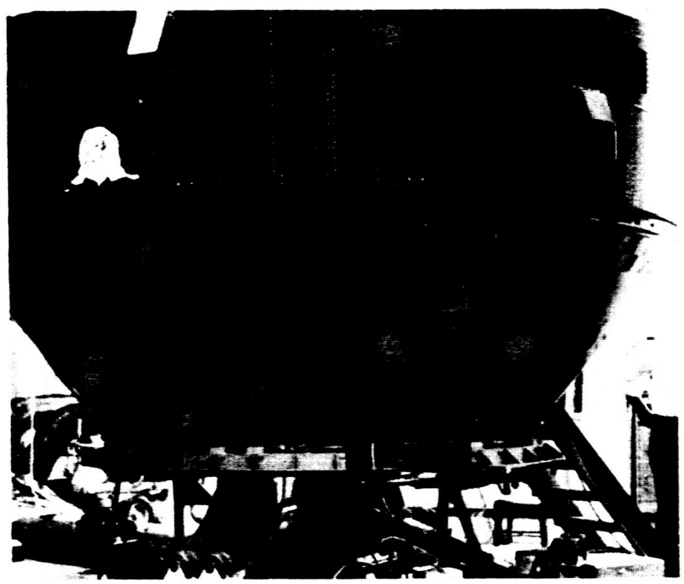

184. Aerial view of MSFC Saturn test stands
185. S-IU-9 checkout

Preparation for the seventh Saturn I flight included installation of a nonpropulsive propellant tank venting system in the second stage to reduce tumbling of the vehicle's payload in orbit.[180] Also, following discovery of "stress corrosion" cracks,

all eight engines were removed from the SA-7 vehicle's first stage and sent back to Rocketdyne where aluminum alloy domes were substituted.[181]

The final three Saturn I vehicles neared completion. Douglas employees at Santa Monica finished inspecting the S-IV-8 stage before its delivery to SACTO for static test. Chrysler personnel at Michoud completed pre-static checkout of the final Saturn I Booster, S-I-10.[182] Meanwhile, MSFC personnel at Huntsville conducted checkout of instrument unit, S-IU-9.[183] Besides these events in July, NASA amended its S-IV stage contract with Douglas to add research and development work valued at more than $21 million.

By mid-July Chrysler at Michoud had clustered all tanks for the first Saturn IB booster, S-IB-1, and by the end of the month installed all eight uprated H-1 engines.[184] Chrysler worked on the second booster (S-IB-2) components and began the

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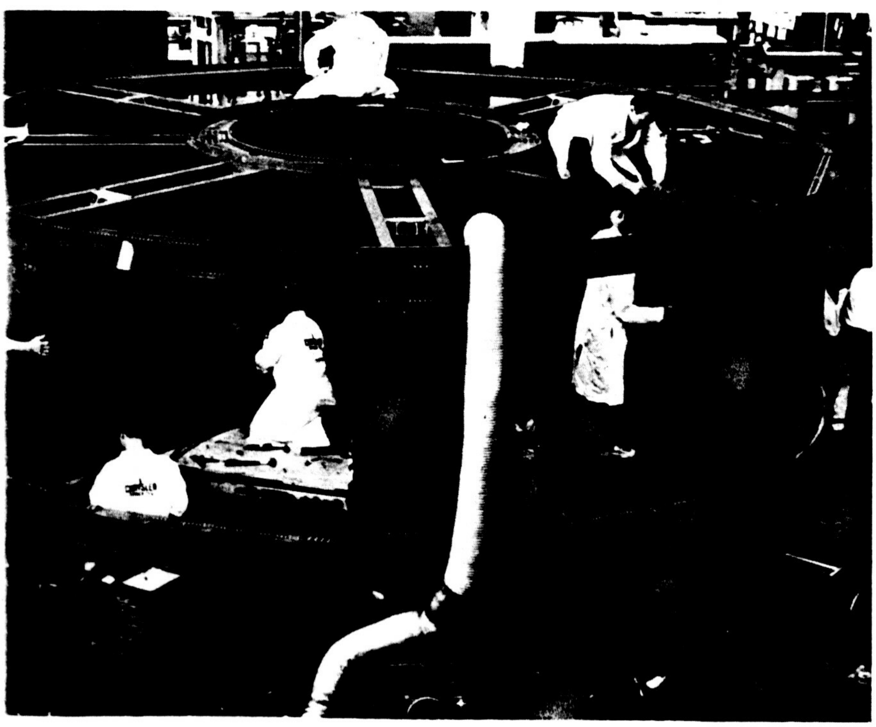

186. Chrysler personnel working on S-IB-2 thrust structure at Michoud

third booster. Chrysler personnel also began converting the Saturn I dynamic test booster to a Saturn IV dynamic test stage. After dynamic tests this stage will be used to check out Kennedy Space Center Saturn IB launch facilities. This modified stage was designated S-IB-D/F.[185] Meanwhile, Douglas second stage (S-IVB) progress during July included insulating the dynamic test stage, rework on the battleship stage, and hydrostatic testing for leaks in the liquid hydrogen tank of the structural test stage.[186] Douglas continued work on ground support equipment.

Saturn V booster production at Michoud was several weeks behind schedule in July; parts shortages

187. Douglas personnel working on ground support equipment at Huntington Beach

187

accounted for some of the delay. Third stage problems included rupture of the S-IVB hydrostatic test stage because of two faulty weld repairs; tests were considered complete, however, because sufficient information had been obtained.

The first of two test stands for the Saturn V second stage (S-II) was completed by North American Aviation at its Santa Susana Field Laboratory in July. On July 11 Douglas delivered its first Saturn V third stage test hardware to Huntsville. Flown from Long Beach, California, this S-IVB stage forward skirt would connect the top of that stage to the vehicle instrument unit.

Saturn V contract action included addition of over $22 million to Rocketdyne's F-1 engine contract for acceleration of combustion stability research and a variety of hardware and services, a $3.6 million J-2 facility contract to Rocketdyne, a

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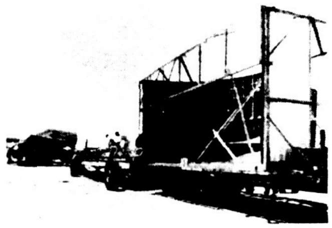

188. First Saturn V hardware from Douglas
189. Blockhouse activity at SACTO during S-IV-9 acceptance firing
190. SA-7 rises

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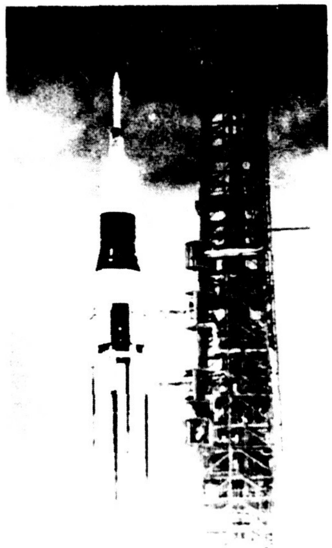

launch vehicle computer contract with IBM, and two contracts for more than $2 million each to Douglas for S-IVB rocket stage items and S-IVB automatic checkout equipment, respectively. On July 13 Army's Corps of Engineers of Mobile, Alabama, acting as NASA's agent for Mississippi Test Operations construction, awarded a contract worth more than $17 million for construction of the first test position on the giant S-IC dual test stand.

On August 6 at Sacramento Douglas personnel successfully acceptance fired S-IV-9, second stage of the SA-9 flight vehicle.[187] During August the Fairchild Hiller Corporation continued work on meteoroid detection satellites to be orbited by the last three Saturn I vehicles. Each satellite, soon after second stage separation and orbit, would extend its wings to a span of 96 feet. During the month NASA named the satellites "Pegasus" after the winged horse of ancient mythology. Problems with their development threatened the schedule of the last three Saturn I launches.[188]

NASA launched its seventh Saturn I from Cape Kennedy on September 18. The two-stage rocket placed approximately 37,000 pounds of payload into an orbit similar to the interim orbit for future three-man Apollo lunar missions (145-mile apogee, 112-mile perigee). Boilerplate Apollo spacecraft command and service modules, instrument unit, and the spent S-IV stage comprised the satellite. All major test objectives were met: final development testing of Saturn I propulsion, structural, guidance, and flight control systems; development testing of Apollo spacecraft structure and design; demonstration of physical compatibility of launch vehicle and spacecraft; and test-jettisoning of spacecraft launch escape system. Cameras ejected after the flight were abandoned because of Hurricane Gladys, but some were later unexpectedly recovered. After this flight Saturn I was declared operational, achieving its goal three vehicles early.[189]

Saturn IB accomplishments by late September included MSFC's strengthening of the structure and start of component assembly for S-IU-200V, a nonflight Saturn IB instrument unit. At Michoud, Chrysler personnel were modifying flight tail section, and other Saturn I test stage components, with a new spider beam. Douglas had completed propellant loading in an S-IVB propulsion test stage, the S-IVB battleship. A Saturn IB program assessment had caused MSFC to extend the test period for this stage and to terminate the all-systems test program. The S-IVB all-systems test stage became a facilities checkout stage. MSFC was reviewing the S-IVB battleship test program on a daily basis, having found that problems with propulsion testing were affecting the Saturn IB second stage development schedule.[190]

Progress on both Saturn V engines was substantial by the end of September. MSFC had conducted a number of F-1 firing tests, and Rocketdyne was testing F-1 engine systems at Edwards. Four J-2 engines had been tested, accepted, and delivered to stage contractors.[191]

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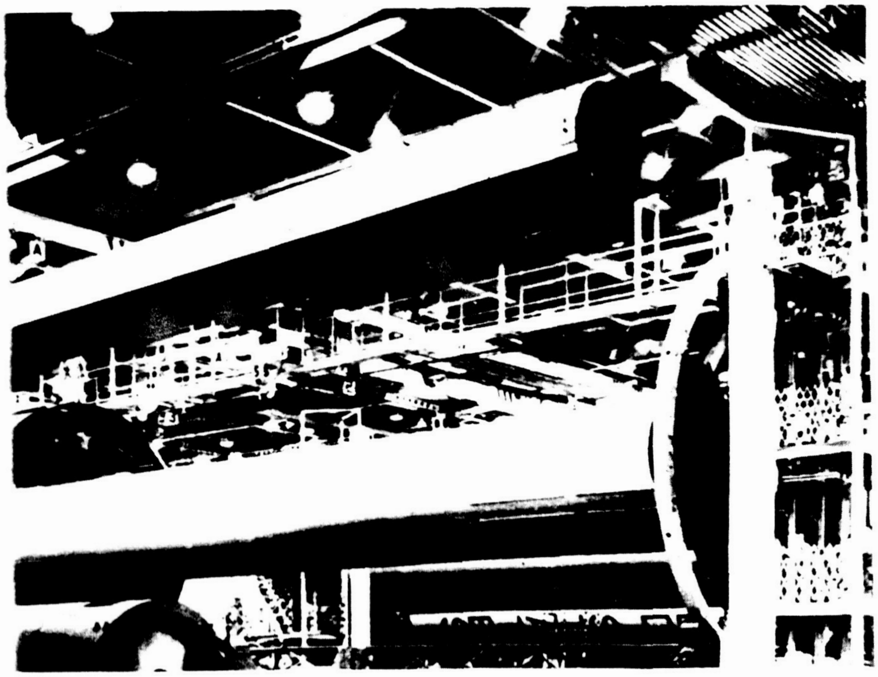

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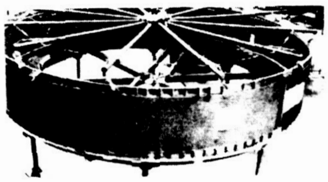

191. Saturn IB nonflight instrument unit
192. Clustering Saturn IB Dynamic Test stage at Michoud
193. S-IB tail section
194. S-IB spider beam

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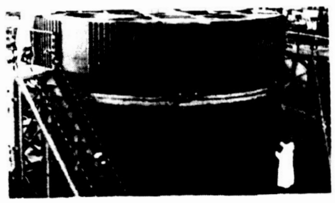

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North American Aviation-S&ID announced completion of a 33-foot-wide bulkhead for the hydrogen-powered Saturn V second stage during September.[192] The Electro-Mechanical Mockup for the S-II stage was completed at Downey, California, but not fully instrumented. Douglas personnel began

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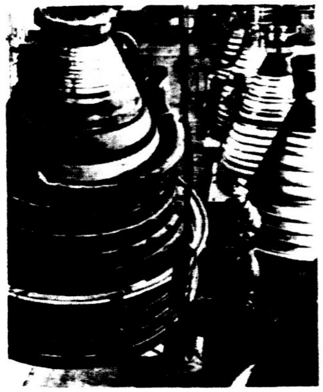

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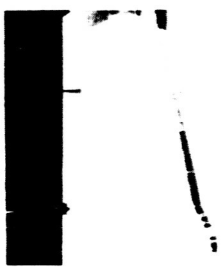

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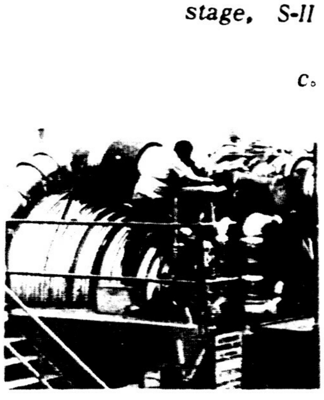

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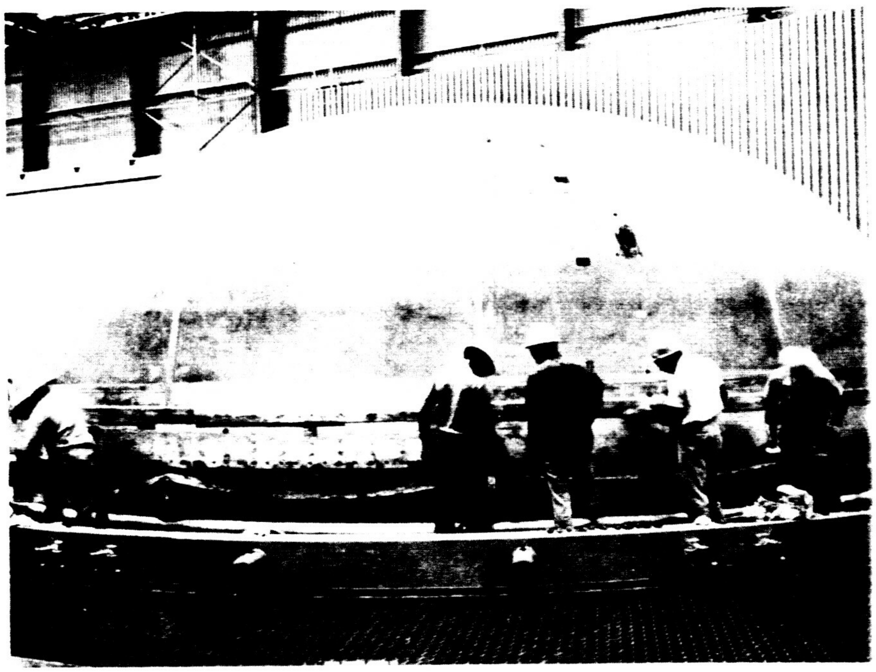

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195. Saturn engine manufacturing by Rocketdyne at Canoga Park; a. J-2 engine assembly, b. F-1 furnace brazing operation, c. F-1 engine assembly

196. Bulkhead for Saturn V second stage

197. Electro-Mechanical mockup for Saturn V second stage, S-II

fabricating the first flight version of the Saturn V third stage, the S-IVB/V-1.

NASA had completed negotiations with Bendix Corporation for the Saturn V instrument unit guidance platforms by the end of the month.

On October 6 MSFC concluded three and one-half years of Saturn I first stage static testing with a test of the final booster. The 156-second test indicated that the S-I-10, manufactured by Chrysler at Michoud, was satisfactory.[193] The major units of the SA-9 vehicle went to the Cape in October, and the other two Saturn I vehicles neared completion. Development of the Pegasus satellites to be carried by the last three Saturn I vehicles proceeded. During October Fairchild Hiller Company conducted tests on a canister designed to provide power, communication, and data electronics for these meteoroid measurement satellites. An adapted Apollo spacecraft service module would protect each satellite from aerodynamic heat before its injection into orbit and operation.

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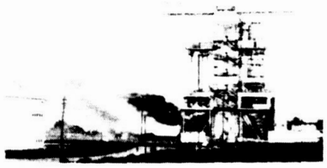

198. Last Saturn I booster ground test

Two flight booster stages for the Saturn IB were visible in the Chrysler Final Assembly Area at Michoud in October. The first, S-IB-1, was ready for inspection before ground test firing. Tank clustering of the S-IB-2 was complete and other assembly operations were under way. Also near completion was S-IB-D/F, dynamic test stage converted from Saturn I. Meanwhile, Douglas had four Saturn IB second stages under way. As these S-IVB flight stages were being manufactured, Douglas was conducting tests of the propulsion subsystems and of engine chilldown procedure before full-duration static firing of the J-2 engine-powered S-IVB battleship.[194]

Progress on Saturn V test facilities was substantial in October. Personnel at the Rocket Engine Test Site at Edwards, California, conducted four consecutive full-duration F-1 engine test firings and approved the operational readiness of the new

stand.[195] Dr. von Braun assigned operation of the site to Rocketdyne after officially accepting it on behalf of NASA. The MSFC Saturn V test complex, Mississippi Test Operations, observed its

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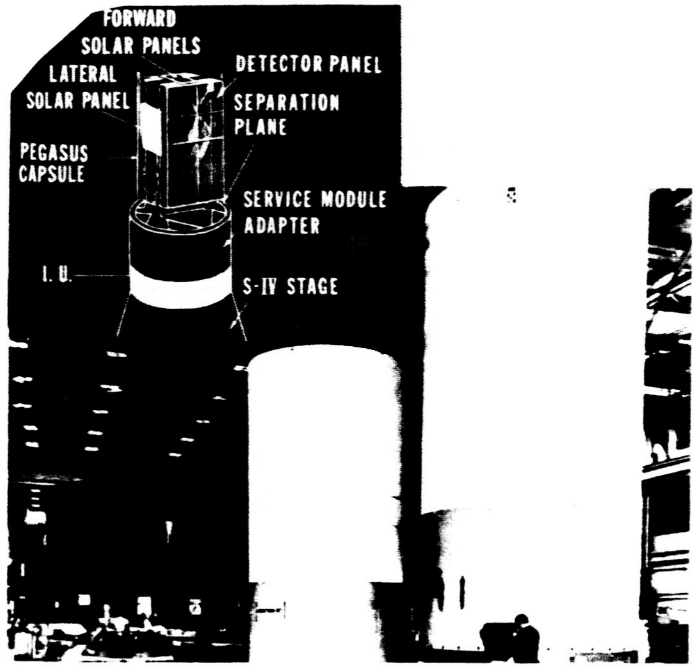

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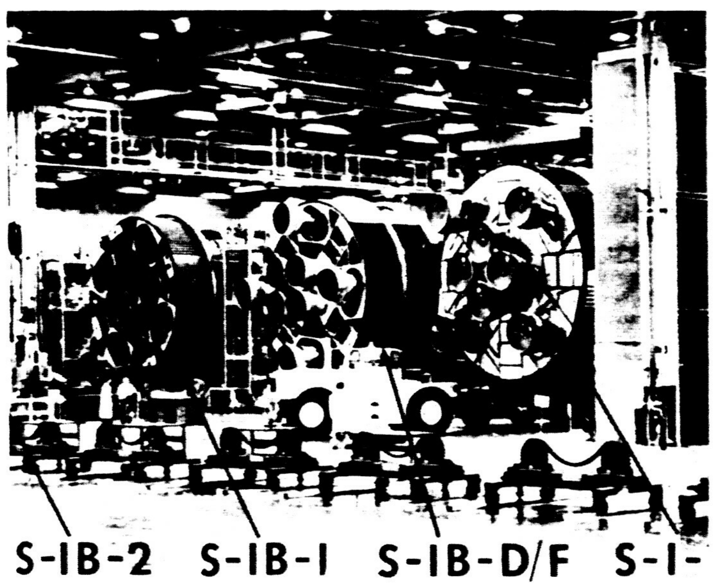

199. Two of three Pegasus satellites for last Saturn I flights housed inside adapted service modules
200. Chrysler Saturn IB booster work; a. S-IB-2, b. S-IB-1, c. S-IB-D/F, d. S-I-10
201. Douglas S-IVB stage fabrication area

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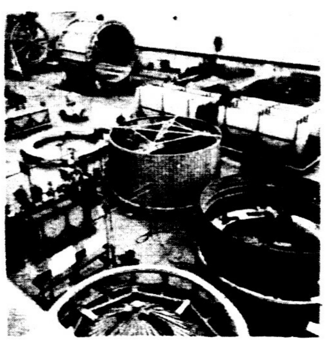

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third anniversary. Mississippi Test Operations will conduct final ground firings of the two lower stages of Saturn V. Testing of the other stage, S-IVB, will occur at facilities in California. S-IVB will have been flight-proven in modified form in Saturn IB flights before its use in Saturn V.

A surprising recovery of films from the seventh Saturn I flight took place in November. Almost two months after the flight, two barnacle-encrusted capsules, each containing 100 feet of color motion-picture film in good condition, were found, one on a beach of an island in the Bahamas, the other in San Salvador in Central America. Hurricane weather had thwarted recovery efforts after the flight.[196]

Other Saturn I activity in November included erection of the SA-9 on the launch pad at Cape

202. F-1 engine test at rocket engine test site, Edwards, California
203. Mississippi Test Operations; a. laboratory and engineering building, b. test stand for second Saturn V stage, S-II, c. test stand for first Saturn V stage, S-IC

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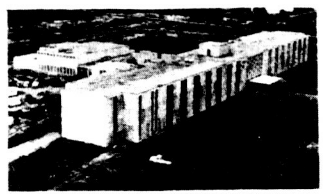

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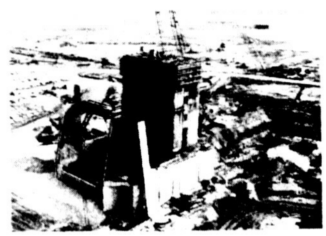

c.

204. Recovered cameras
205. S-IV-10 being moved to stand at SACTO
206. Chrysler Saturn IB fabrication and assembly area at Michoud
207. Auxiliary propulsion system for Saturn IB second stage

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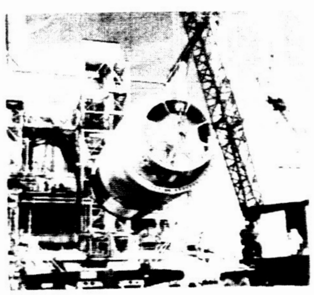

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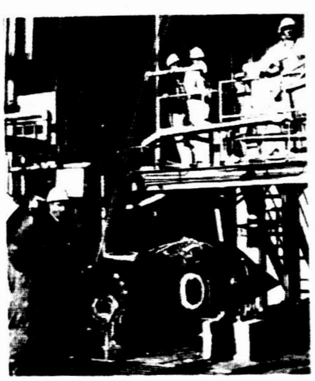

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Kennedy. The SA-8 vehicle, to fly after SA-9, progressed; post-static checkout of the S-I-8 stage neared completion, instrument unit checkout was under way, and the S-IV-8 stage was acceptance fired.[197] Stages of SA-10, the final vehicle, were manufactured; Chrysler was making minor modifications and repairs in the S-I-10 stage before post-static checkout, Douglas transferred the S-IV-10 stage to the Sacramento facility where it would be acceptance fired, and in Huntsville MSFC was assembling the S-IU-10 components on schedule. Development problems on the Pegasus satellite, payload for remaining Saturn I vehicles, were being solved, and there was considerable test activity on parts of the prototype satellite.[198]

With the first Saturn IB booster complete, Chrysler continued manufacture and assembly of the next three during November. Technicians removed engines from the first booster, S-IB-1, and shipped them to Neosho for LOX dome retrofit. Engines would be reinstalled at Michoud before delivery of the stage to MSFC for static test. At SACTO Douglas employees test fired, for the first time, the auxiliary propulsion system for the

Saturn IB second stage, S-IVB. This system consists of six 150-pound thrust engines which provide attitude control after the main engine (J-2) shuts down and the S-IVB stage enters into the coast phase of flight. In Huntsville MSFC finished assembly of a nonflight Saturn IB instrument unit, S-IU-200V. On November 24 a successful S-IVB battleship firing occurred.

NASA provided for construction of Pad B of NASA's Saturn V Complex 39 at Merritt Island, Florida, by an almost $20 million firm-fixed-price contract awarded in November. At MSFC the first Saturn V booster stage, S-IC-T, a nonflight version, was partially assembled;[199] the Center used parts primarily from the Boeing Company. Douglas was checking out the S-IVB dynamics test stage, manufacturing S-IVB flight stages, and conducting propulsion systems tests. On November 24 a successful S-IVB battleship firing took place.[200] The Saturn V second stage, S-II, activity by North American Aviation included, on November 9, a successful single engine ignition S-II battleship test, hydrostatic tests of the common bulkhead test tank which certified repairs, and buildup of

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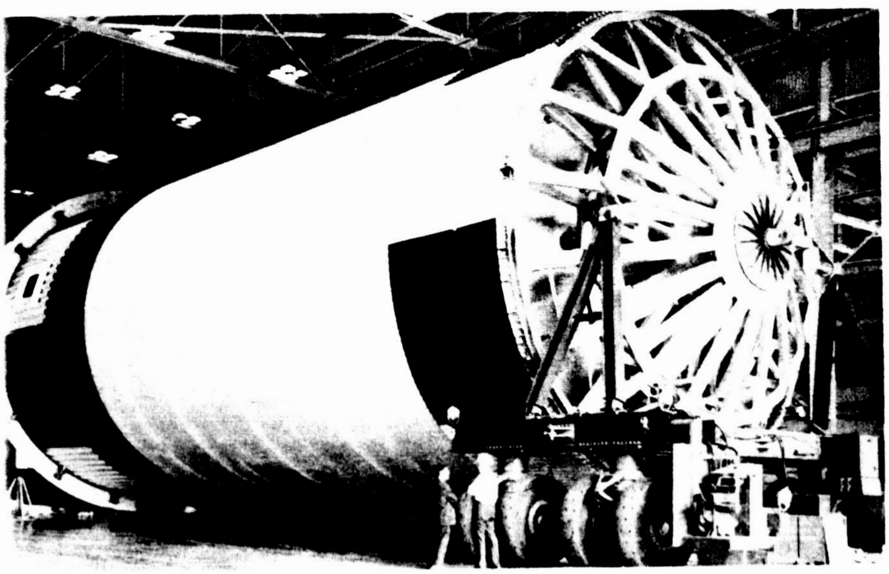

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208. First Saturn V booster, a nonflight version for static tests
209. First short-duration S-IVB battleship firing

the structural test vehicle, S-II-S.

By the end of December Saturn I launch preparations at Cape Kennedy were proceeding on schedule toward the established SA-9 flight date. The S-I-8 stage was ready for shipment but would be stored for a brief period before February shipment to the Cape since SA-9 would fly ahead of SA-8.[201] Fairchild Hiller was fabricating Pegasus B. General Electric Company had finished vibration and vacuum tests on Pegasus A. On December 29 Pegasus A, the first meteoroid detection satellite, arrived at Cape Kennedy from where the SA-9 would boost it into space and orbit of the earth.

Saturn IB's first flight stage booster, S-IB-1, was in pre-static checkout in December. Chrysler was completing installations in assembled S-IB-2 units and assembling spider beam for S-IB-3. Others began assembling the S-IB-4 tail section. Meanwhile, test booster S-IB-D/F was modified,

210. Buildup of Saturn V second stage, nonflight version for tests

211. Pegasus B, folded, at left, and Pegasus prototype in space-craft integration area of Fairchild Hiller Company, Hagerstown

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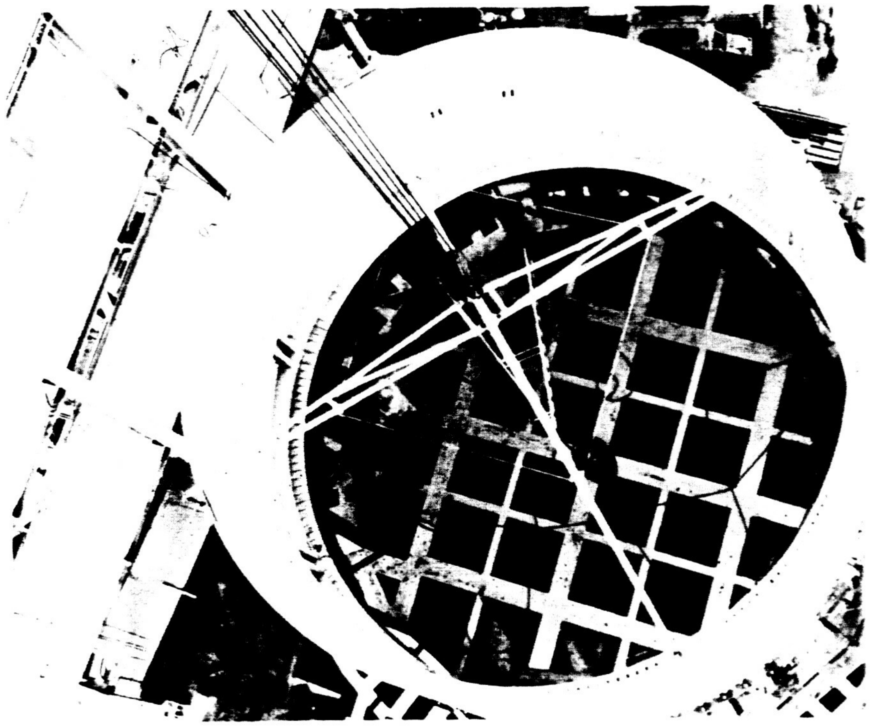


reclustered, prepared for shipment, and on December 22 departed New Orleans for Huntsville for dynamic testing. Douglas shipped the first completed S-IVB stage, S-IVB-D, a structural replica of the flight stage, from Huntington Beach on December 8.[202] First and second Saturn IB stages and an Apollo spacecraft were scheduled to be united for complete vehicle tests in MSFC's 200-foot-tall Dynamic Test Stand.

During December Douglas accomplished a series of test firings of the S-IVB battleship stage at SACTO. On December 23 a full-duration (415-second) firing of the battleship occurred.[203]

Contract for a new Saturn V test stand was signed in December. This second S-II test stand at Mississippi Test Operations will cost over $8 million. The U. S. Army Corps of Engineers, Mobile District, construction agent for NASA's Mississippi Test facilities, awarded the contract to Malon Construction Company of Koppers Company, Inc. In Huntsville MSFC prepared for the first single-engine firing of the Saturn V test booster S-IC-T and perfected ground support equipment. MSFC's Manufacturing Engineering Laboratory (ME Lab) manufactured and assembled the LOX bulkhead of structural test stage S-IC-S in less than a month, setting a new record for building a bulkhead.[204]

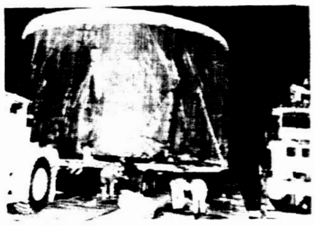
212

213

212. Saturn IB test first stage being readied for shipment

213. First Saturn IB test second stage, S-IVB-D, at turnover ceremony at Douglas

From Michoud Boeing shipped to MSFC a 33-foot-diameter S-IC stage thrust structure for structural testing.[205] Other Boeing work included building the first Saturn V fin constructed away from Marshall Center. North American Aviation-Rocketdyne accomplished Flight Rating Tests (FRT) of the F-1 engine; five of these would power the Saturn V first stage. Saturn V second-stage accomplishments included North American Aviation-S&ID's testing of J-2 engine gimballing on the Electro-Mechanical Mockup at Downey, California;[206] replacement of LOX bulkhead of the S-II-S; a load and pressure test of the S-II stage; and completion of S-II battleship single engine firings. A major milestone during December was North American Aviation-Rocketdyne's completion of Preliminary Flight Rating Tests (PFRT) of the J-2 engine; five of these would power each Saturn V second stage and one would power the third stage.



Two Saturn IB test stages arrived at MSFC on January 4, 1965; the S-IB Dynamic/Facilities

214. S-IC-S thrust structure on barge at Michoud

215. Internal ribs of first Boeing-built Saturn V fin, assembled and ready for attachment of skins

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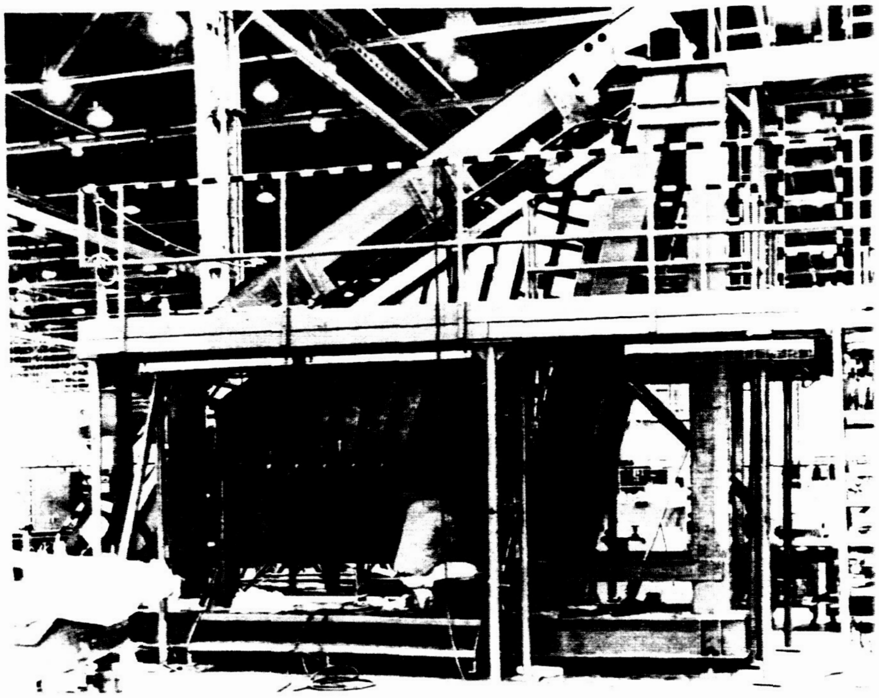

checkout stage, S-IB-D/F, from Chrysler Corporation's Space Division at Michoud and the S-IVB Dynamic stage, S-IVB-D, from Douglas.

On January 7, ME Lab began structural fabrication of S-IU-200S/500S.

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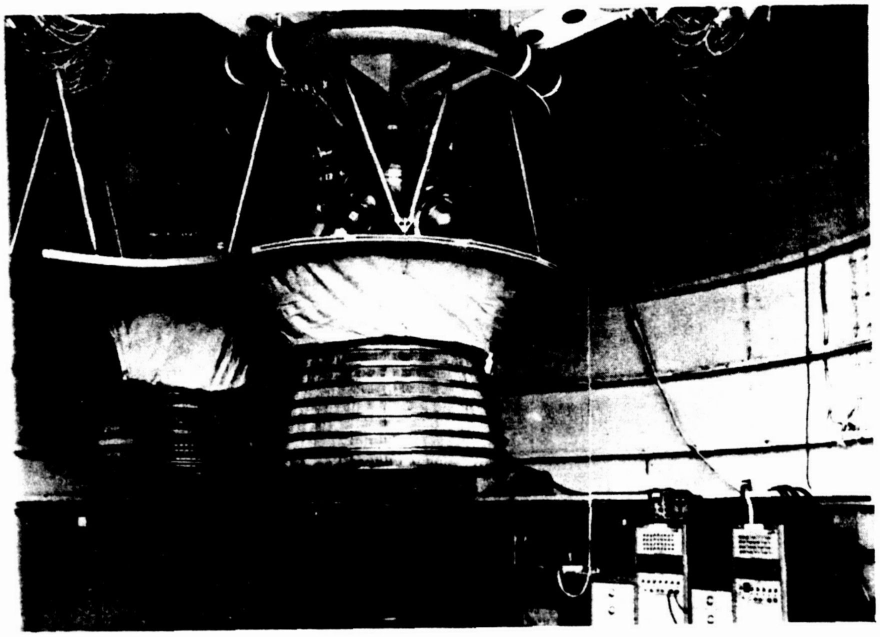

216. J-2 Engine gimballing test
217. Replacement of S-II-S bulkhead

On January 13 technicians at KSC attached Pegasus A, encased in its Apollo service module shroud and adapter, to the S-IV-9 stage in preparation for scheduled launch. The following day at Launch Complex 37B technicians mated the Apollo BP-16 Command Module to the Apollo Saturn (AS-9) vehicle.[207]

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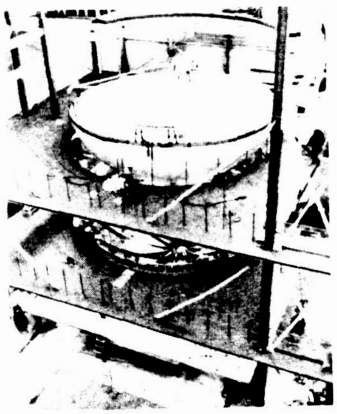

At Douglas Aircraft Company's Sacramento Test Center on January 21 there was a successful full-duration static firing for 480 seconds of the Saturn I S-IV-10 stage. On this same date the S-IB stage contractor, Chrysler, began clustering propellant tanks for the S-IB-3 at the Michoud Facility and, at MSFC, ME technicians completed assembly of the S-IU-10 and structural fabrication of S-IU-200D/500D and began component assembly on the latter.[208]

Barge Service Building at Mississippi Test Operations.[214] On this same date S-IU-200F/500F component assembly began at MSFC. Also technicians completed structural fabrication of S-IU-200S/500S.

Douglas completed final assembly of the S-IVB facilities checkout stage, S-IVB-500F, on February 12 and turned the stage over to NASA at Seal Beach. Workmen then loaded it aboard the NASA barge Orion for transportation to SACTO.[215] At KSC technicians completed the countdown demonstration test for SA-9.

With launch only two days off, MSFC and Fairchild-Hiller Corporation technicians at KSC modified Pegasus A on February 14 so that one frame or logic group of the wind panels could serve as a detector for radiation-induced meteoroids.[216]

On February 16 NASA launched from KSC the Saturn I SA-9 vehicle. It performed excellently during the flight and placed the Apollo boilerplate spacecraft, BP-16, and the first Pegasus satellite into separate orbits. The Pegasus A satel-

222. *Meteoroid measurement capsule*
223. *SA-9 launch at Kennedy Space Center*

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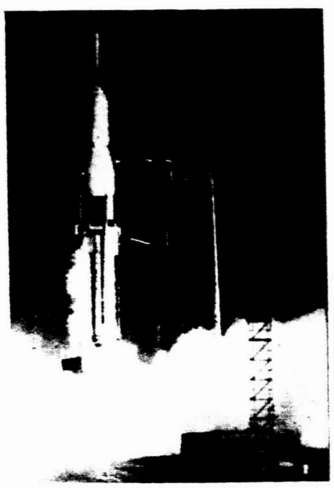

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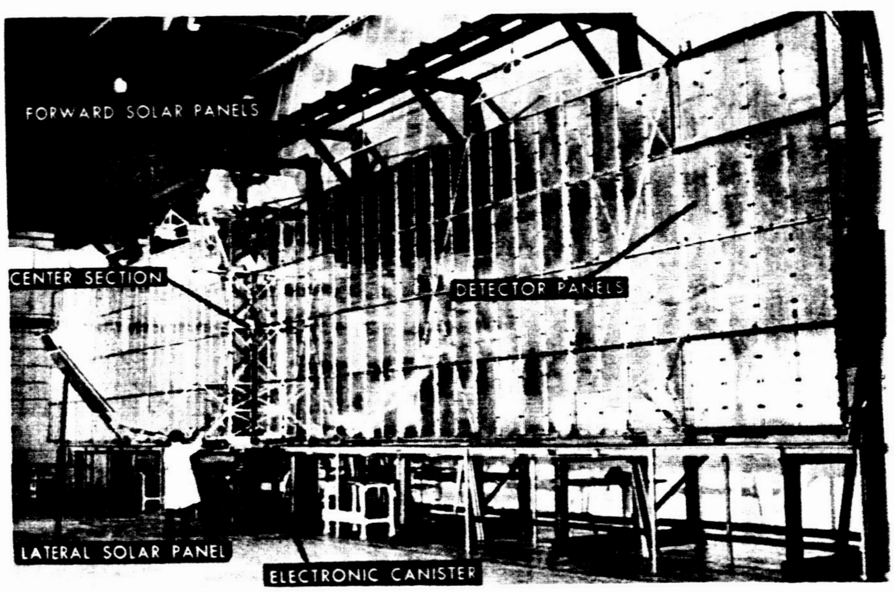

lite deployed its "wings" to a span of 96 feet and exposed 2300 square feet of instrumented surface to gather meteoroid data, sort the information, and transmit it to earth receiving stations. NASA launched SA-9 instead of SA-8 on this date because SA-9's S-I stage, built in-house, had progressed through manufacture and testing more rapidly than had S-I-8.[217]

The S-IVB-500F arrived at SACTO February 17 and installation began in Beta III test stand. On February 19 MSFC ME Lab began structural fabrication of S-IU-500FS.

Douglas shipped S-IV-8 to KSC from SACTO on February 23.[218] Also on this date Douglas personnel completed post-static checkout and repair of the S-IV-10 stage and removed the stage from Test Stand Beta II at SACTO. The following day Douglas initiated pre-static checkout of the first flight S-IVB stage, S-IVB-201, at the Space Systems Center at Huntington Beach.[219]

On February 28 the first industry-produced Saturn I first stage, S-I-8, arrived at KSC from Michoud.[220]

During February fabrication of major structural subassemblies for S-II-1 had begun at Seal Beach. Also during February NASA modified the H-1 engine research and development contract to include uprating the H-1 from 188,000 pounds thrust (188K) to 200K for Saturn IB application. NASA approved modifications to the Rocketdyne H-1 engine production contract converting it from cost-plus-fixed-fee (CPFF) to cost-plus-incentive-fee. (CPIF).[221]

On March 1, 1965, workmen ahead of schedule moved the S-IC-T out of MSFC's ME Lab and on to the static test stand where they erected it in the stand. The following day MSFC shipped the instrument unit for SA-8 (S-IU-8) to KSC while technicians erected the S-I-8 stage on Launch Complex 37B at the Cape.

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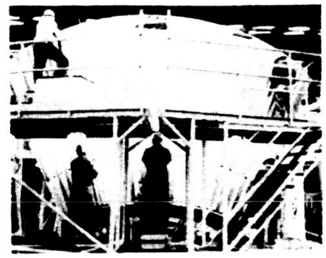

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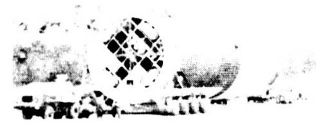

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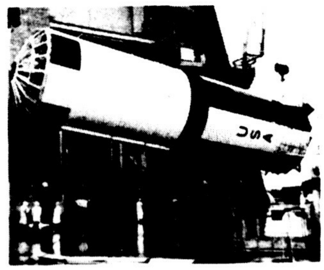


224. S-II-1 thrust structure fabrication at Tulsa
225. S-IC-T en route from ME lab to test stand
226. Erection of S-IC-T in test stand at MSFC

The S-IB-1 stage left Michoud aboard the barge Palaemon for MSFC on March 6. Eight days later the stage arrived at MSFC. Meanwhile, on March 10, ME Lab technicians completed component assembly and structural modification of S-IU-200S/500S.

On March 15 Chrysler technicians placed the S-IB-1 into a static test stand at the MSFC complex in Huntsville, and began readying the stage for static firing.[222] This same date the S-IU-200S/500S arrived at MSFC's structural test facility.

KSC technicians at Launch Complex 37B on March 17 erected the S-IV-8 stage and the S-IU-8 atop the S-I-8 stage and began a series of systems tests including radio frequency checks, tanking procedures, and simulated flights.[223]

Technicians at Michoud on March 24 installed the S-IC-D thrust structure in the vertical assembly building.

On March 26 NASA and Boeing signed a supplemental agreement incorporating a new Saturn V delivery schedule called Plan VIII.

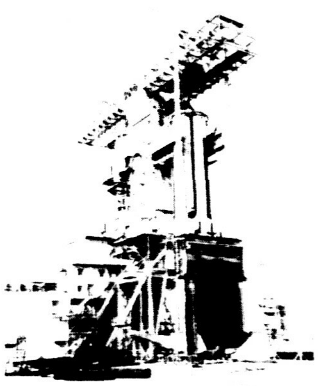
At MSFC, on March 29, S-IU-500V structural fabrication began. The following day S-IU-500FS component assembly began. NASA on March 31 approved award of the Saturn IB/V instrument unit contract to IBM. This contract (NAS8-1400) was the first major incentive contract to be negotiated in the Saturn IB program.[224]

In March NASA delineated specific management roles for the Saturn IB/Centaur System to MSFC and Lewis Research Center. MSFC received project management for the Saturn IB/Centaur System and Lewis management of the Centaur System.

In the Saturn IB program on April 1 the S-IB-1 performed successfully in its first static firing,

227. Saturn IB Booster being moved into static test stand
228. Positioning S-IV on S-I at KSC

227



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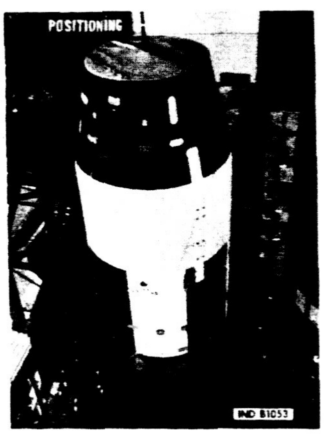

with engine cutoff initiated by the control operator after 35 seconds. Also on April 1 in the IB program NASA authorized Rocketdyne to increase the 200K H-1 engine to 205K to support Saturn IB application to even larger missions.[225]

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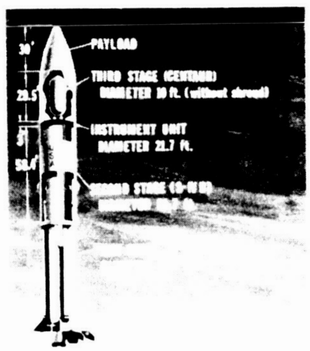

229. Saturn IB/Centaur Configuration; a. payload, b. Third Stage (Centaur) diameter 10 feet (without shroud), c. instrument unit diameter 21.7 feet, d. second stage (S-IVB) diameter 21.7 feet, e. first stage (S-IB) diameter 21.4 feet

On April 7 Major General Samuel C. Phillips, Director, Apollo Program, NASA, forwarded to MSFC an amendment to the FY 65 Research and Development Appropriations. This authorized transfer of $5 million to the Saturn IB Program

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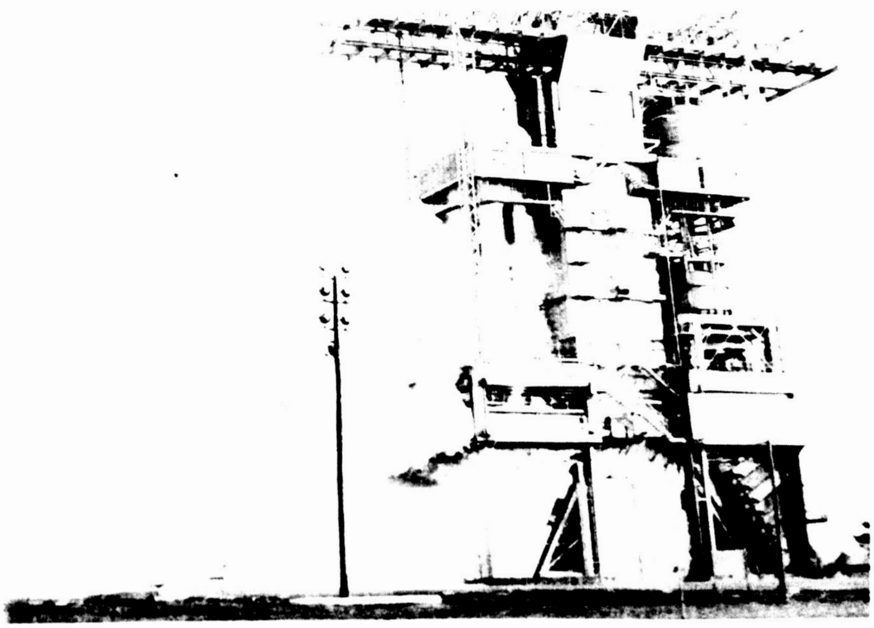

230. Static firing of S-IB-1 at MSFC

231

231. Static test of all five engines of Saturn V booster (S-IC-stage)

for Saturn IB/Centaur design effort.[226]

The first single-engine S-IC-T firing occurred at MSFC on April 9.

Apollo Spacecraft BP-26 arrived at KSC on April 10 and entered receiving inspection. Also on this date MSFC successfully test fired a single F-1 engine on the stage for 16.73 seconds. Three days later Chrysler test personnel successfully static fired the S-IB-1 stage the second time at MSFC; the test lasted 142 seconds. The next day, April 16, Marshall personnel successfully test fired all five of the S-IC-T stage's F-1 engines. This first

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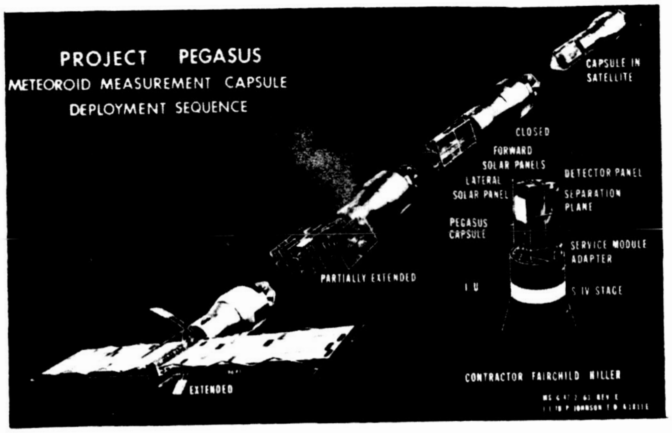


S-IC-T five-engine test occurred two months ahead of schedule and lasted 6.5 seconds. [227]

On April 20 workmen loaded the S-IB-1 stage on board the Palaemon for its return trip to Michoud to undergo post-static checkout and modification. [228]

Pegasus B, second of the micrometeoriod detection satellites, arrived at KSC on April 21 to be readied for launch.

MSFC on April 22 began negotiating with Chrysler for an equitable adjustment to contract NAS8-4016. This resulted from NASA program redirection and termination of six S-I stages. Negotiations would continue throughout 1965.

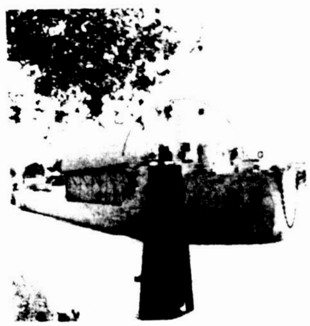
On April 24 the S-IB-1 arrived at Michoud from MSFC where it had undergone static tests. On this same date, at Santa Susana, S&ID conducted the first five-engine ignition test of the S-II battleship. [229]

MSFC on April 29 completed assembly of the S-IU-200F/500F.

The S-IVB contractor loaded the first flight S-IVB stage aboard the NASA barge Orion on April 30 for shipment to SACTO. Also on April 30, during the final test of S-II-S at Seal Beach, a failure occurred that seriously damaged the stage. [230]

232. Deployment sequence of the Pegasus
233. S-IVB-201 enroute to Courtland, California, aboard the Orion

233



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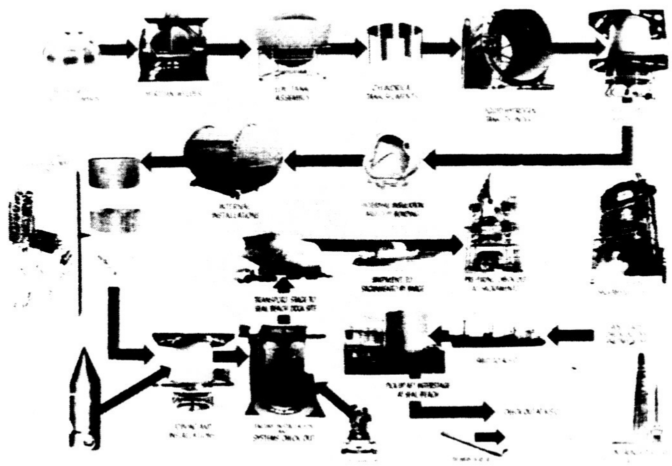

234. S-IVB Production Sequence

S&ID activity during April included installation and checkout of Electro-Mechanical Mockup systems, beginning vertical assembly of S-II-F, and the first test to ultimate load on the S-II-S/D. In April also, NASA modified a Boeing contract to provide engineering services and instrumentation for the Saturn V dynamic test program.

On May 4 the S-IVB battleship stage successfully performed a hot-gimbal, full-duration firing at SACTO to conclude the Saturn IB battleship hot-firing test phase.[231] The following day S-IVB-201 arrived at Courtland, California, aboard the barge Orion. There workmen unloaded it and placed it on the S-IVB transporter for the remainder of its journey to SACTO. The next day, May 6, S-IVB-201 arrived at SACTO, and preparations began immediately for positioning it in the Beta III test stand.

On May 7 at Santa Susana there was a successful 10-second cluster firing of the S-II battleship after two previous unsuccessful attempts.[232]

Douglas on May 10 delivered the tenth and last Saturn I S-IV stage (S-IV-10) to KSC aboard the Pregnant Guppy aircraft.

MSFC submitted the procurement plan for nine additional Saturn V S-IVB stages to the NASA

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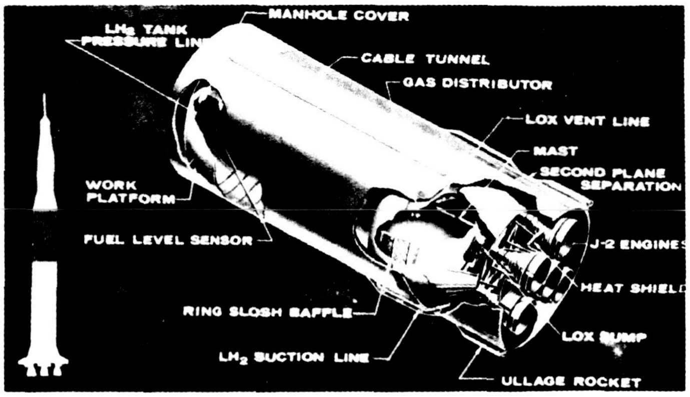


Office of Manned Space Flight (OMSF) on May 17 for approval.

Final period of countdown for the SA-8 launch started on the afternoon of May 24 and, except for a scheduled 35-minute hold, continued uninterrupted to liftoff. Liftoff occurred the next day, May 25, as SA-8 flew in the ninth successful Saturn I flight. SA-8 placed in orbit Pegasus B.[233]

Workmen on May 25 successfully completed vertical assembly of the S-II-T, in progress at Seal Beach since February. On May 26, the first stage S-I-10, for the tenth and last Saturn I launch vehicle left Michoud on the barge Promise for KSC.

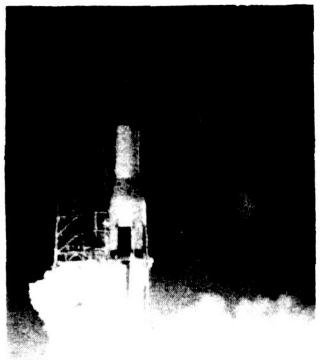
During May MSFC and Rocketdyne completed negotiations for conversion of the J-2 contract to an incentive type.[234] Also in May S&ID structural assembly of the S-II-2 flight stage began at Seal Beach. And technicians at SACTO began conversion of the S-IVB battleship from the Saturn IB to the Saturn V configuration.

S-IU-10, final instrument unit for the Saturn I vehicles, arrived at KSC from MSFC on June 1, a day before KSC technicians erected the S-I-10 on Launch Complex 37B.

On June 8 the launch support crew at KSC erected

235. S-II stage
236. Launch of SA-1 from pad 37B at KSC

236



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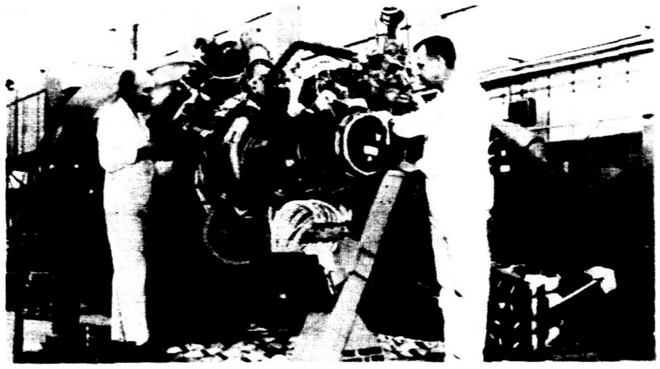

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237. Rocketdyne technicians checking out a J-2 engine
238. Point Barrow, Carrier for S-IVB-500F Stage

the S-IV-10 atop the S-I stage on Launch Complex 37B. KSC technicians on June 9 erected the S-IU-10 on the SA-10 vehicle and began connecting umbilicals of the launch support equipment.

CCSD shipped the S-IB-2 stage on June 12 from Michoud to MSFC.

After arriving at Seal Beach from SACTO on the barge Orion, the S-IVB-500F stage on June 13 went aboard the USNS Point Barrow for its trip to KSC via the Panama Canal.

MSFC workmen completed structural assembly of S-IU-500V on June 14.[235]

The S-IB-2 stage arrived at MSFC's Huntsville dock on June 19 from where Chrysler and MSFC personnel moved it to the static test tower in preparation for a series of acceptance firings. The S-IU-200F/500F left MSFC on this date en route to Michoud to await reshipment to KSC. At KSC it would be used in facilities checkout of Launch Complex 34. On June 19 at SACTO test

personnel attempted the first Saturn V development firing of the S-IVB battleship; the test ended after several seconds because of an automatic cutoff.[236]

The Apollo BP-9 service module and service module adapter, modified by MSFC to serve as a shroud for the Pegasus C experiment, arrived at KSC on June 21. Meanwhile at KSC, to avoid delay of the SA-10 launch and also delay of planned Launch Complex 37B modification, NASA shifted the launch to July 30, ahead of the Gemini 5 launch.[237]

In a last captive-firing condition test at MSFC S-IC-S on June 21 withstood 140 percent of the design load.[238]

The Fairchild-Hiller Corporation shipped the third

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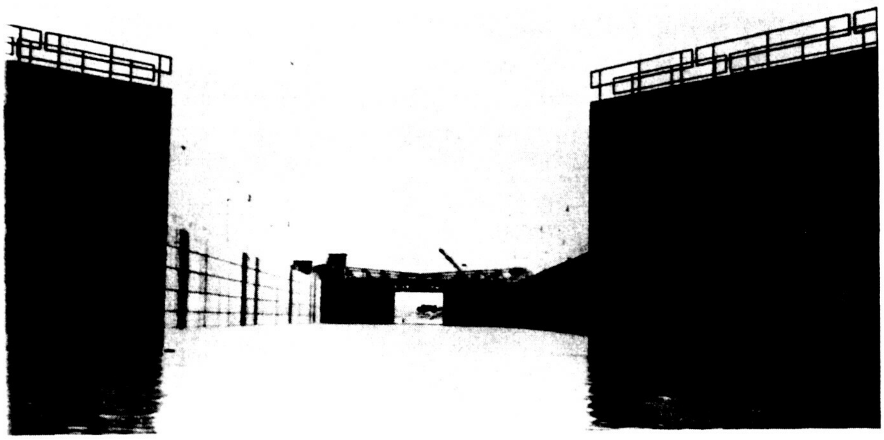

meteoroid detection satellite, Pegasus C, to KSC on June 22 aboard the Pregnant Guppy aircraft.

After investigating ways to reduce the complexity of the Saturn/Apollo onboard communications and tracking systems, MSFC on June 28 recommended and NASA approved deletion of the MISTRAM transponder and use of the more reliable AZUSA "C." Both were not required for program success.[239] On this date also the S-II stage simulator became the first "space age" hardware to pass through the

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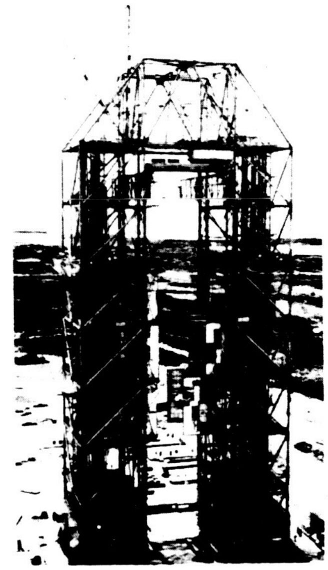

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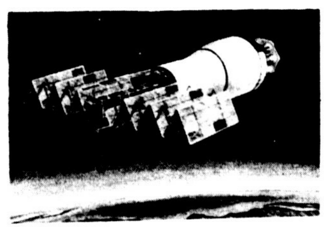


239. Launch Complex 34 gantry at KSC

240. Pegasus with partial deployment of wings

241. Opening of locks at MTF

Mississippi Test Operations lock and into the site's seven and one-half mile canal system.

The Point Barrow arrived at KSC on June 29 with the S-IVB-500F. Arriving at KSC on June 29 was the last boilerplate version of the Apollo spacecraft command module. It arrived from MSFC along with the launch escape system.

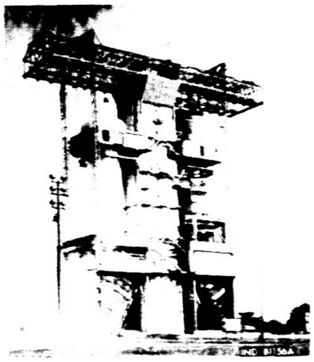
During June MSFC began contracting negotiations with Rocketdyne for the 22 remaining engines needed for the 12 Saturn IB vehicles. S&ID technicians at Seal Beach began assembly of S-II-3, the third Saturn V flight stage.

A July 1 "third firing" of the Saturn IVB battleship stage (Saturn V configuration) at SACTO resulted in an explosion and fire that damaged wiring and instrumentation.[240]

On July 2 NASA at KSC awarded a $6,745,000 construction contract to adapt Launch Complex 37 for Saturn IB. Also at KSC, following completion of premating systems checks and panel deployment checks, technicians on July 6 attached Pegasus C to the S-IU-10 instrument unit. They then positioned BP-9 as the shroud for the satellite. A July 6 Saturn V milestone occurred at Seal Beach, California, as workmen began vertical buildup of the S-II-1.[241]

242. S-IB static test Huntsville

242



After a suggestion by NASA Administrator James E. Webb, the name of the Mississippi Test Operations was officially changed to Mississippi Test Facility (MTF).

A faulty signal from the engine pressure switch on July 8 automatically ended a first attempt to static fire S-IB-2 in the S-IB test stand at MSFC. The test, conducted by Chrysler personnel, lasted only three seconds. But the following day the S-IB-2 stage successfully performed a short-duration 35-second captive firing in the stand.[242] On July 12 component assembly of the S-IU-500ST started at ME Lab. A 27-second S-II battleship

firing occurred at Santa Susana Field Laboratory (SSFL) on July 13; this was the longest firing to date of the S-II program.[243]

The S-IB-2 stage successfully completed its series of static tests at MSFC with a 2.5-minute full-duration test on July 20.[244]

In the Saturn V program, on July 20 technicians at SSFL successfully accomplished a 150-second firing of the S-II battleship. The KSC launch crew successfully performed the countdown demonstration test for SA-10 on July 27. Final phase of countdown for the SA-10 launch was under way at 9:25 PM EST on July 29 and continued to liftoff without any technical holds. On July 30 SA-10, in the final flight test of the Saturn I program, performed excellently. The launch vehicle inserted its dual payload of Pegasus C and BP-9 into an orbital trajectory. This SA-10 flight concluded NASA's Saturn I program.[245]

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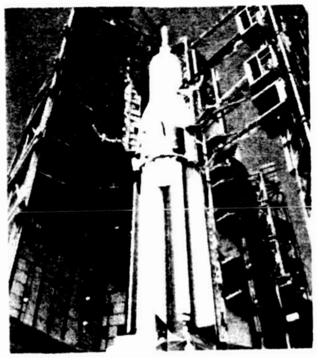

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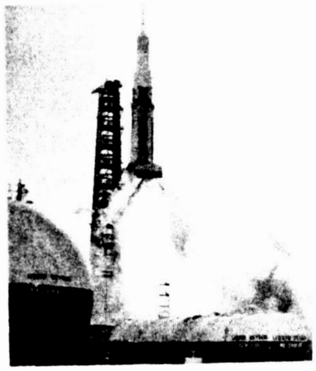

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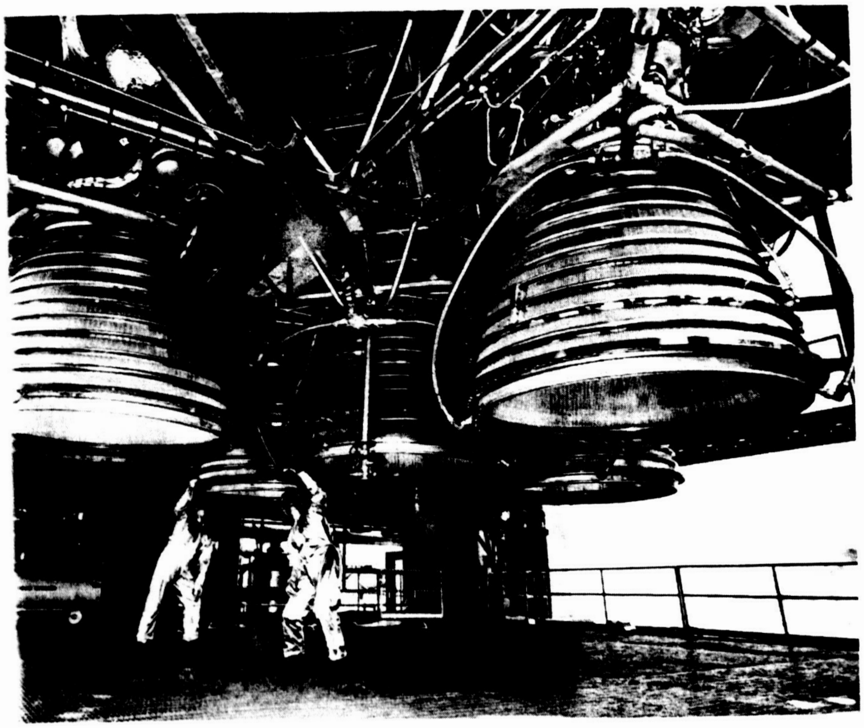


243. Saturn SA-10, during countdown demonstration test

244. Launch of SA-10 from pad 37B, KSC

245. Technicians checking Rocketdyne-built J-2 engines on S-II stage

The second Saturn IB booster (S-IB-2) left MSFC's Huntsville port aboard the barge Palaemon on its return trip to Michoud on July 30.

A component malfunction in Pneumatic Console A at SACTO prematurely ended the first attempt to static fire S-IVB-201. But stage propellant loading and the automatic countdown sequence proceeded satisfactorily to the point of cutoff in this July 21 static firing.[246]

During July in support of the Saturn IB and V programs Rocketdyne completed the flight rating tests of the 200K J-2 engine at SSFL. Also in July, Rocketdyne initiated a development program to uprate the J-2 engine thrust capability from 200K to 230K.[247]

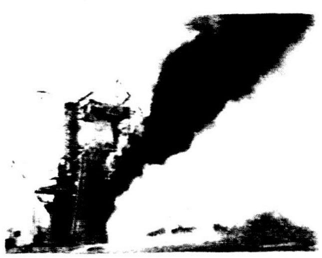
On August 2 MSFC personnel conducted the first successful ignition test of the MSFC S-IVB battleship. It lasted for 2.1 seconds. This first firing of the MSFC S-IVB battleship completed activation of the J-2/S-IVB test stand at MSFC.[248]

The first full-duration run of S-IC-T occurred at MSFC on August 5. The firing lasted 143.6 seconds.[249]

The S-IVB-201 stage successfully performed a full-duration firing of 452 seconds at SACTO on

246. S-IC static firing
247. Computer room during S-IVB-201 firing at Sacramento

246



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August 8. The test was computer-controlled throughout, marking the first use of a fully automatic system for performing a complete checkout, propellant loading, and static firing of a vehicle stage.[250]

On August 9 Chrysler shipped the first Saturn IB flight booster, S-IB-1, to KSC. The stage would be used in launch facilities checkout and then readied for flight.

In the Saturn V program, on August 9 S&ID at SSFL accomplished a full-duration S-II battleship cluster firing; it terminated manually after 385.6 seconds.[251] And the structure of the S-IU-200S/500S on August 13 withstood 140 percent load limit at MSFC, proving its structural integrity.[252] Meanwhile, Boeing workmen at Michoud began final assembly of the S-IC-4 thrust structure.

The S-IB-1 and S-IU-200F/500F arrived at KSC on August 14 aboard the barge Promise from Michoud. This cargo was the first barged through the new Port Canaveral Locks.

249

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248. S-II battleship cluster firing at SSFL
249. S-II A-2 test stand, Mississippi Test Facility

The first two-burn full-duration firing of the S-IVB battleship lasted 170 and 320 seconds, respectively, at SACTO on August 17.[253]

At KSC workmen transported the S-IB-1 stage to Launch Complex 34 and erected it on the pad on August 18. MSFC used the stage as a spacer for the S-IVB-F during propellant tankings to verify the facility LOX and liquid hydrogen loading systems. On this same day workmen also completed erection of the S-IVB-500F stage and the S-IU-200F/500F on Launch Complex 34 at KSC and began vehicle checkout of the Saturn IB launch facilities. Also on August 18 Chrysler personnel at Michoud completed pre-static checkout of S-IB-3.

Conclusion of the Saturn V S-IVB battleship test program occurred at SACTO on August 20 with a two-burn test for 170 and 360 seconds.[254] Meanwhile, at MSFC on this date technicians completed S-IU-500V assembly and delivered it to test contractor.

On August 29 MTF operations began with installation of S-II stage simulator into Test Stand A-2 for facility checkout.

The S-IVB-202 stage arrived at SACTO from Huntington Beach on September 1. The following day Douglas technicians installed the stage on the SACTO Beta III test stand and continued stage modification not accomplished at Huntington Beach because of parts shortages and design changes.[255] Then on September 3 Douglas transported the S-IVB-201 to the Courtland dock, loaded it on board the Orion, and shipped it to Richmond, California, where it would be loaded on the ocean freighter Steel Executive for the rest of its journey to KSC.[256]

On September 8 workmen at SACTO removed the S-IVB battleship from the Beta I stand and shipped it to Tullahoma, Tennessee, for engine environmental testing.

250. S-IVB-201 being hoisted on the Steel Executive

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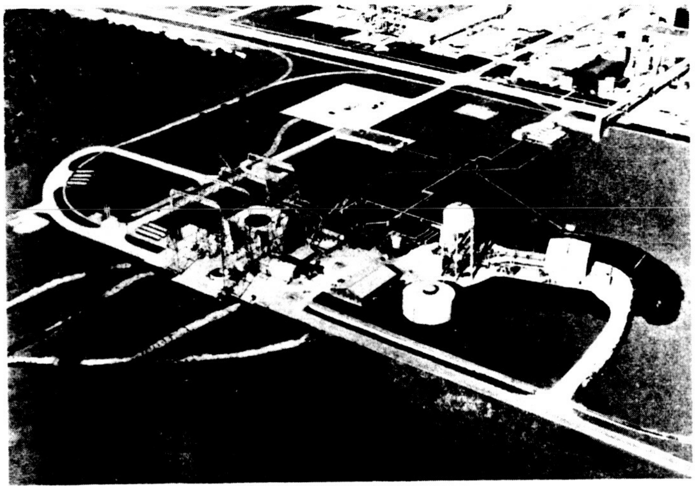

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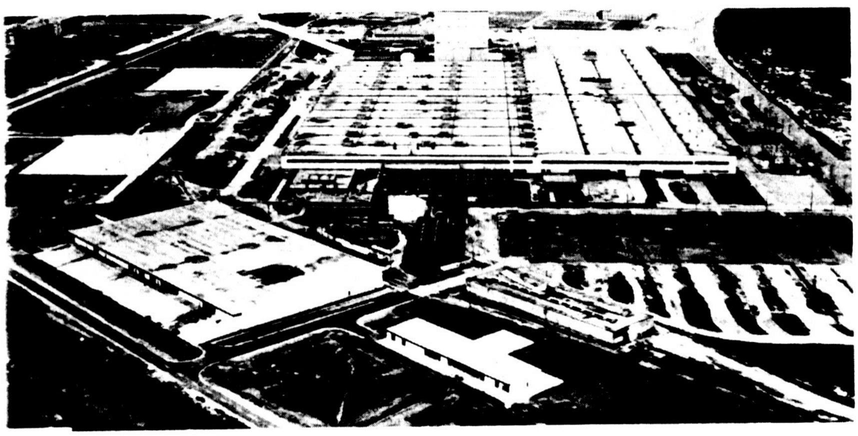

251. Altitude simulation test facility at Tullahoma, Tennessee

252. Aftermath of Hurricane Betsy at Michoud

Hurricane Betsy entered the Michoud area about 8 P.M. on September 9 and left severe roof and building damage at Michoud. It also washed the NASA barge Promise upon the levee, inflicting damage to the barge in the amount of $89,138. The NASA barge Palaemon, with the S-IB-3 stage as cargo, weathered Hurricane Betsy near Baton Rouge, Louisiana, without damage during the first day of its journey from Michoud to MSFC in Huntsville.

IBM on September 9 delivered to NASA the flight launch vehicle digital computer and launch vehicle

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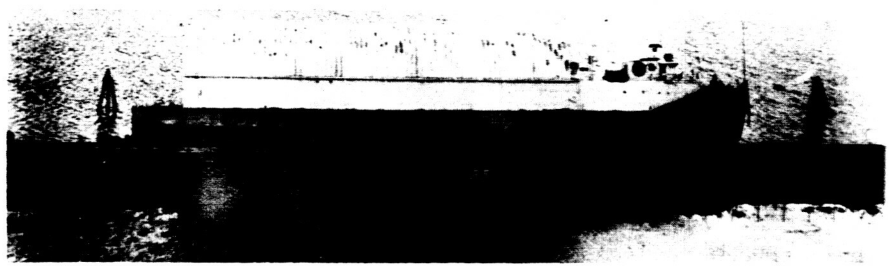

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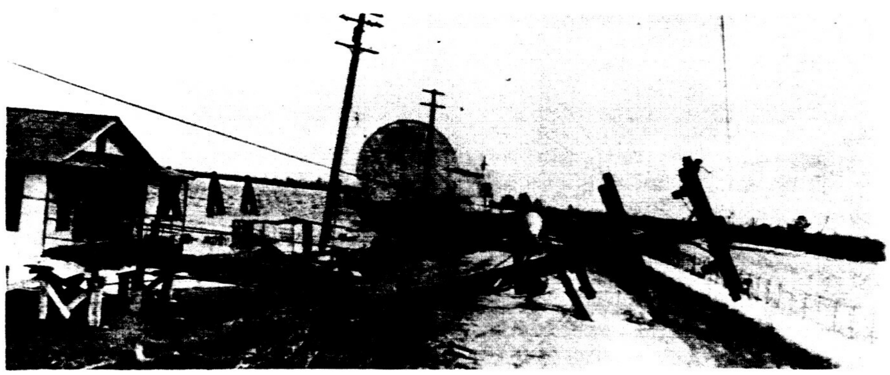

253. *Damage at Michoud by Hurricane Betsy*

254. *NASA barge Promise upon levee after Hurricane Betsy*

255. *Hurricane Betsy leaves Promise on levee*

data adapter (LVDC/LVDA) for the SA-201 vehicle.[257]

The upper stage testing in the Saturn IB dynamic test program ended at MSFC on September 11. S-IVB battleship at MSFC fired for 400 seconds on September 15, a full-duration test.[258] On September 16 the S-IB-3 arrived at MSFC where Chrysler test engineers would static fire the stage in MSFC's S-IB test stand before returning it to Michoud.

The S-IVB-201 arrived at KSC aboard the <u>SS Steel Executive</u> September 19; workmen unloaded the stage and moved it to the special assembly building for receiving inspection.

On September 29 the S-II-S/D ruptured and disintegrated during a structural loading test at Seal Beach. The failure occurred at 144 percent of limit load on the aft skirt. This failure necessitated redirection of the S-II program by substitution of the S-II-T as a dynamic test vehicle

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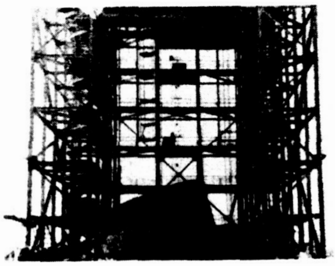

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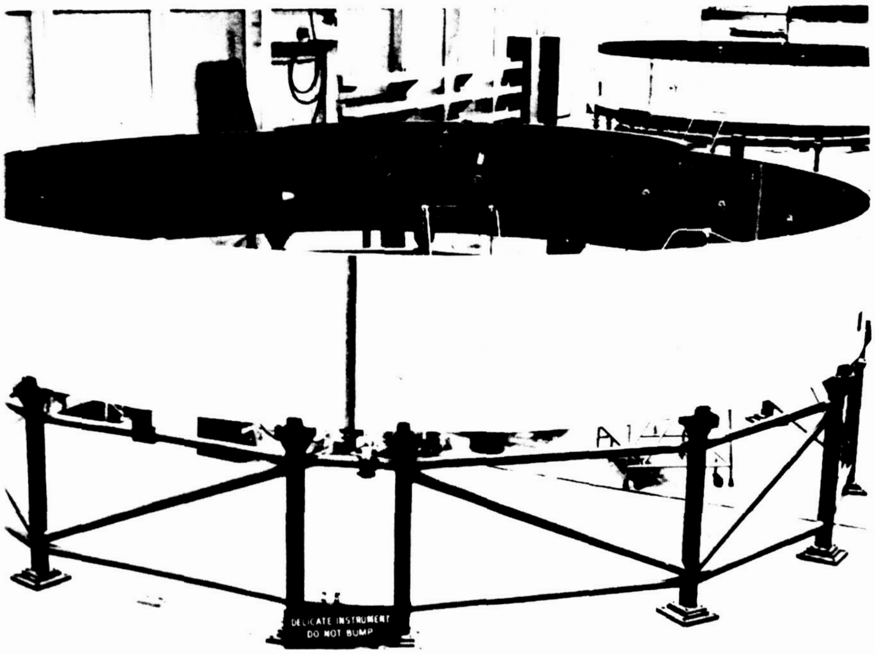

256. S-II-S/D ruptured during structural loading test

257. S-IU-200/500S on fabrication stand No. 1

following static testing at MTF.[259]

Workmen at Seal Beach completed manufacture of the S-II-T stage on September 30. Meanwhile, on this date IBM at Huntsville completed fabrication of the S-IU-200S/500S-II.[260]

During September NASA added to the Boeing contract (NAS8-5608 Schedule II) $4.5 million to provide services in connection with systems engineering and integration of mechanical GSE.

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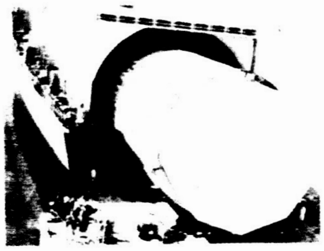

258. Loading S-II-T on AKD ***Point Barrow***

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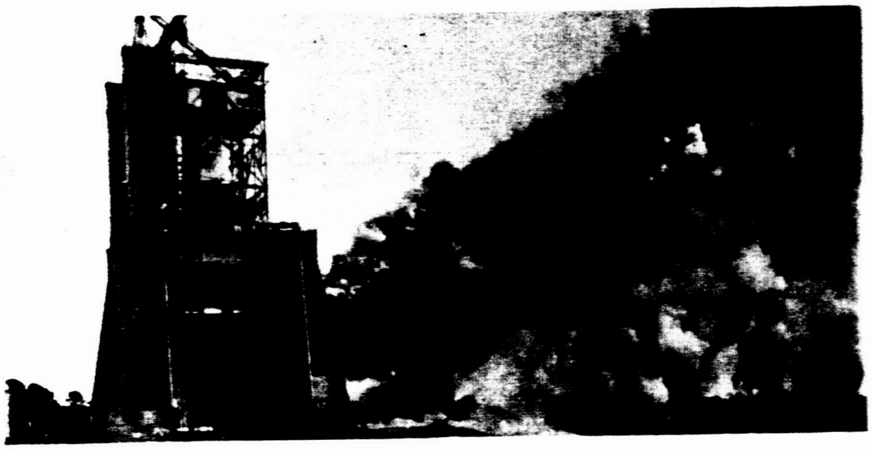

259. S-IC-T static test firing

Workmen at KSC on October 1 mated the S-IVB flight stage for AS-201 (S-IVB-201) to the S-IB-1 stage on Launch Complex 34.[261] Also on October 1 NASA approved a two-year incentive contract with Pratt & Whitney for follow-on RL10 engine research and development effective this date. The contract covered qualification of RL10-A-3-3 (uprated version) for Centaur application and continued flight support. In the Saturn V program on October 1 the S-II-T, S-II all-systems stage, left Seal Beach on the Point Barrow bound for MTF.

On October 6 workmen at Michoud completed assembly of the S-IB-4 stage, and the stage entered pre-static checkout.

The first S-IC-T firing in automatic configuration occurred at MSFC on October 8 for a scheduled

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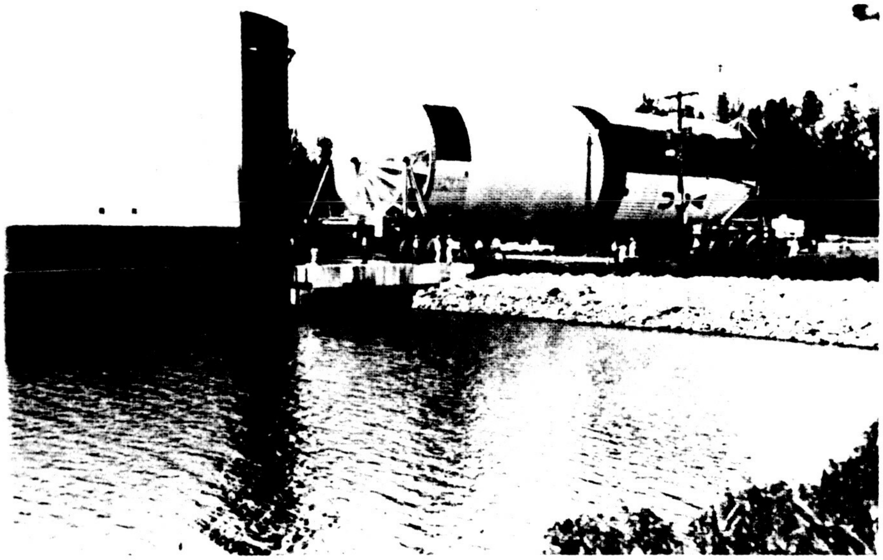

duration of approximately 45 seconds.[262] On October 13 the S-IC-D arrived at MSFC's Saturn V dock after leaving Michoud dock aboard the barge Poseidon October 6, the Poseidon's first trip. Two days later technicians at MSFC began Saturn V dynamic testing of the S-IU-200D/500D.

The S-II-T, first "live" launch vehicle stage at MTF, arrived October 17 for start of stage all-systems testing. S&ID personnel at MTF placed S-II-T into Test Stand A-2 on October 19.[263] The S-IU-201 arrived at KSC on October 20 aboard the Palaemon: workmen unloaded it and took it to hangar AF for prelaunch checkout. Five days later technicians at KSC erected the S-IU-201 atop the S-IVB-201 stage on Launch Complex 34. That same day, October 25, Apollo Command Module 009, part of the payload for the AS-201 vehicle, arrived at KSC and entered checkout.

Douglas technicians on October 26 completed the S-IVB-202 pre-static firing checkout at SACTO. On this date S-IB-3 successfully performed a 2.5-minute static firing in the S-IB static test stand at MSFC in Huntsville.[264]

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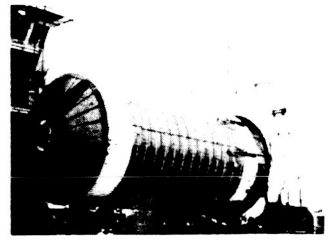

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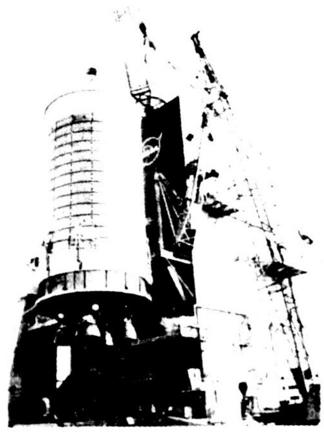
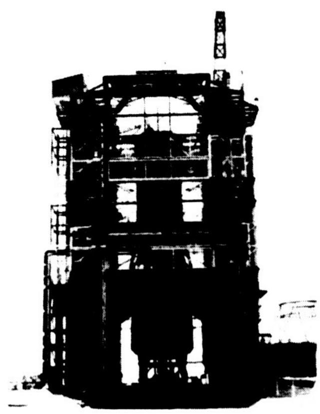


260. S-IC-D being unloaded from barge Poseidon
261. S-II-T arriving at S-II-A2 stand at MTF
262. Installation of S-II-T in MFT test stand A-3
263. S-IVB-202 installed in Test Stand Beta 3 at SACTO

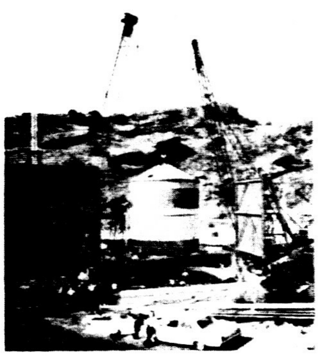
263



264. *H-1 engine*
265. *S-II common bulkhead test tank (CBTT)*

264

265



On October 28 Rocketdyne delivered to Chrysler at Michoud the first two H-1 engines uprated from 200K to 205K. Eight of the uprated engines would add about 40,000 pounds thrust to the S-IB stage and increase the total thrust of the stage to 1,640,000 pounds.[265]

Difficulties experienced with the stage electric power system at SACTO terminated the first S-IVB-202 acceptance firing attempt on October 29.[266] Also on October 29, the S-IVB stage contractor shipped S-IVB-203 to SACTO.

During October construction of the Launch Complex 39 pad A ended at KSC.

NASA on November 1 increased Chrysler's contract NAS8-4016 some $18,909,000 to cover additional systems engineering. In the Saturn V program on this date the Propulsion and Vehicle Engineering (P&VE) Laboratory at MSFC began the first series of S-IU-200S/500S-II tests.

On November 2 the second S-IVB-202 acceptance firing attempt ended at SACTO after 0.41 seconds of mainstage because of a component malfunction in the J-2 engine combustion stability monitoring system.[267] SACTO activated Test Stand Beta I on November 3 with installation of S-IVB-203.

The final scheduled test of the S-II common bulkhead test tank (CBTT) ended at Santa Susana on November 6. The CBTT was tested to 1.4 times the limit burst pressure. Completion of these tests, which verified the integrity of the common bulkhead, the liquid hydrogen tank, and the forward skirt, was a major milestone in the S-II stage program.[268]

On November 8 the Saturn IB stage S-IB-3 arrived at Michoud from Huntsville to undergo post-static checkout and modification. The next day the S-IVB-202 stage performed a long-duration (307 seconds mainstage) acceptance firing at SACTO;

a malfunctioning liquid hydrogen mass sensing unit in the propellant utilization (PU) subsystem prevented completion of the test to full duration.[269] Pre-static checkout of S-IB-4, completed at Michoud on this date, revealed no significant problems.

Workmen at Seal Beach completed all S-II-1 major subassemblies on November 25 with assembly of the aft LOX bulkhead.

There was a November 30 automatic LOX loading test of the S-IB-1 at KSC to verify the automatic LOX loading and replenish systems and the LOX drain systems. The stage withstood a LOX load of 100 percent; during the loading all stage systems functioned normally.[270] On this data Chrysler technicians completed assembly of S-IB-5 and moved it into the checkout station for pre-static checkout.

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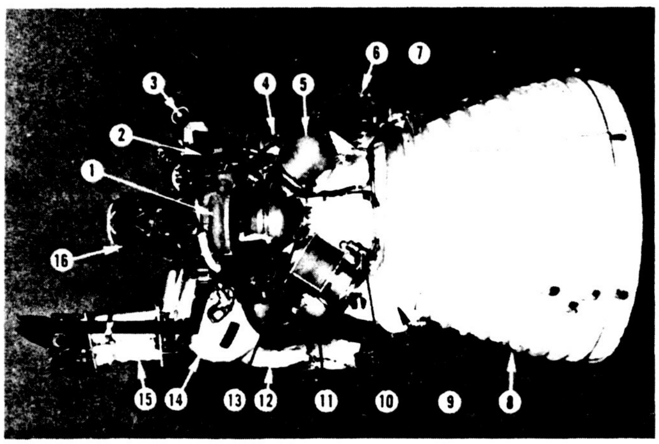


1 OXIDIZER TURBOPUMP
2 PROPELLANT UTILIZATION VALVE
3 HIGH-PRESSURE OXIDIZER DUCT
4 ELECTRICAL CONTROL PACKAGE
5 PRIMARY FLIGHT INSTRUMENTATION PACKAGE
6 HIGH-PRESSURE FUEL DUCT
7 FUEL MANIFOLD
8 THRUST CHAMBER
9 EXHAUST MANIFOLD
10 ANTI-FLOOD CHECK VALVE
11 AUXILIARY FLIGHT INSTRUMENTATION PACKAGE
12 CUSTOMER CONNECT LINES (ELECTRICAL)
13 ACCESSORY DRIVE PAD
14 GH_2 START BOTTLE
15 CUSTOMER CONNECT LINES (PNEUMATIC)
16 OXIDIZER INLET DUCT

266. Major components of J-2 engine

In November NASA announced that the J-2 engine contract would be amended to add 48 engines. NASA in addition asked Rocketdyne to provide 52 additional J-2 engines for delivery in 1967 and 1968.[271] November also saw the completion at Seal Beach of all engine deliveries for S-II-1 and S-II-2.

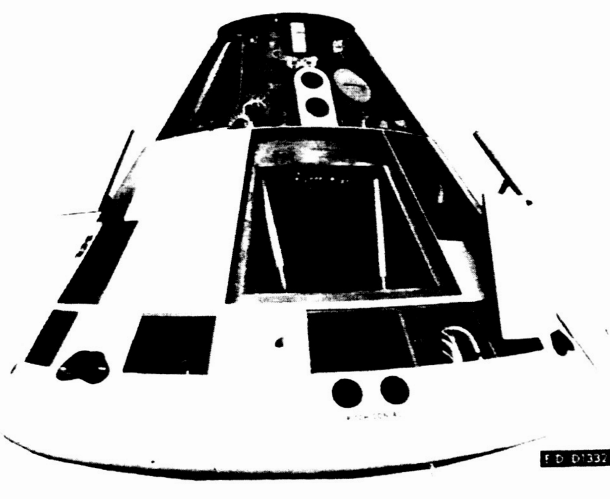
On December 1 the S-IVB-202 stage successfully achieved all test objectives during its full-duration (463.8 seconds mainstage) acceptance firing at SACTO. Cutoff occurred automatically when the PU system indicated less than one percent LOX.[272]

MSFC and Boeing on December 3 negotiated a supplemental agreement establishing Schedule III (Saturn V launch operations support) effective December 31, 1965. In the Saturn V program on December 16, the final captive test firing of the S-IC-T in original automatic configuration occurred at MSFC.[273]

The S-IB-4 stage departed Michoud on December 7 aboard the NASA barge Palaemon for the MSFC test site at Huntsville. MSFC workmen on December 14 unloaded the stage from the Palaemon, moved it to the MSFC static test tower,

267. Apollo capsule

267



and completed its installation in the tower. The following day, also in the Saturn IB program, Douglas completed Phase I of the S-IVB-204 pre-static checkout and successfully performed a simulated flight test before beginning preparations for shipping the stage to SACTO.

Qualification testing of the J-2 engine at the 200K level, which began on December 2, ended successfully at SSFL on December 17.[276]

Technicians at KSC erected Apollo Spacecraft 009 atop the SA-201 launch vehicle at Launch Complex 34 on December 26. With the addition of the spacecraft the vehicle became the Apollo/Saturn 201 (AS-201).[277]

On December 29 MSFC forwarded to NASA Headquarters for approval a supplement providing for conversion of the Boeing S-IC stage contract to cost plus incentive fee; the cost-effective date of this change was July 2.

During December MSFC initiated negotiations with Rocketdyne for a combined J-2 research and development contract NAS7-190 from a CPFF to a CPIF contract. In December preliminary data from the three Pegasus flights indicated that the Saturn Apollo spacecraft structure as designed would be adequate to resist meteroid penetration.[278] Two F-1 turbopump explosions occurred, one at SSFL and one at Edwards.

MSFC announced on January 3, 1966, its negotiation of two nine-month study contracts to determine the feasibility of using an improved J-2 rocket engine in the S-II and S-IVB stages of the Saturn V launch vehicle: (1) a $148,000 contract to North American Aviation, developer of the S-II stage, and (2) a $225,000 modification to an existing contract with Douglas Aircraft Company. MSFC's Propulsion and Vehicle Engineering Laboratory was seeking to simplify the J-2 and give it and the stages it powered more flexibility.[279]

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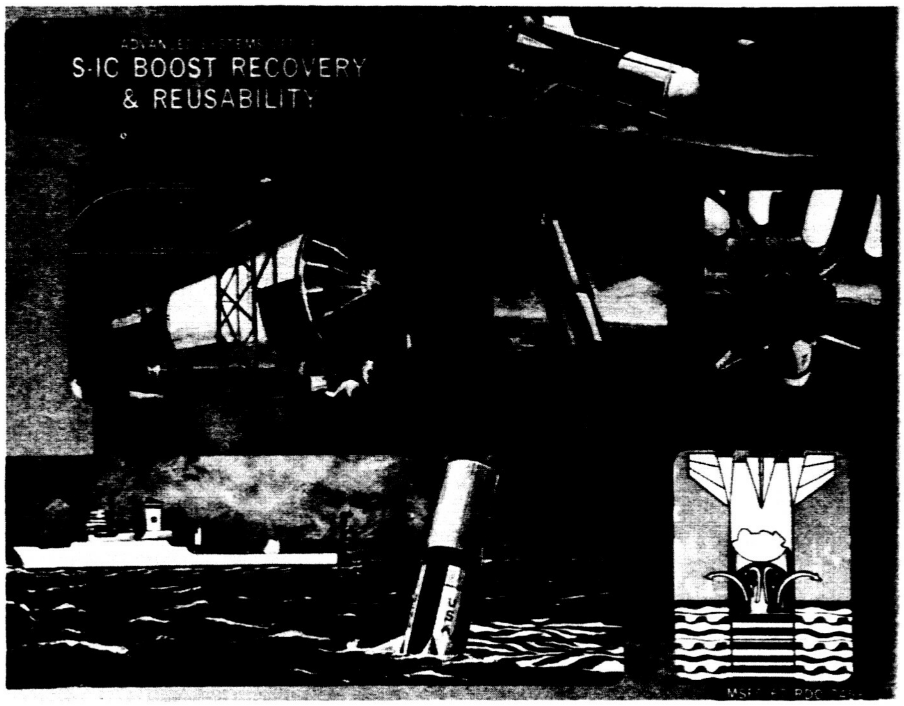

268. *Studies on reusable transport system*

On January 4 MSFC announced the awarding of seven new Saturn contracts, five of them to Saturn prime stage contractors for continuation of studies aimed at improving S-IB and Saturn V launch vehicles. North American, Boeing, and Chrysler each received one of the contracts. Douglas received two. The remaining two of the seven contracts were for continuation of engineering studies relating to a manned reusable transport system: (1) a nine-month $237,000 contract to Lockheed Aircraft Corporation to study possibilities of developing a reusable transport system based on presently approved launch and space vehicles and (2) a six-month $51,000 contract to Martin-Marietta Corporation for a comparison study of launch modes for reusable launch vehicles. Both contracts would be under MSFC's direction.[274]

NASA announced on January 7 the award of a $7,837,500 contract to the Radio Corporation of

269

270

269. S-II battleship firing, Santa Susana
270. S-IC-D erected in S-IC test stand MSFC

America, Aerospace Systems Division, Van Nuys, California, effective December 1, 1965, for logistic support of Saturn ground computer checkout systems. Under the two-year contract, managed by MSFC, RCA would provide spare parts, logistic management, maintenance support, and report services for the Saturn ground computer checkout systems. On this same date MSFC announced that the Air Force's Arnold Engineering Development Center (AEDC) near Tullahoma, Tennessee, was being expanded for test of a third stage (S-IVB battleship) of NASA's Saturn V launch vehicle.[275]

A ground-test (battleship) version of S-II, second stage of the Saturn V, was static fired at Santa Susana, for 354 seconds in a successful January 12 test of its engine-gimballing and LOX cutoff systems.

Saturn V milestones on January 13 involved the first stage and instrument unit. The S-IC-D booster went into the Dynamic Test Stand at MSFC on this date, and NASA awarded a $4,183,066 modification to its existing Saturn V instrument unit contract with IBM's Federal Systems Division, Rockville, Maryland. The modification was for manufacturing "redundant switch selectors."

At Michoud on January 14 a Saturn V launch vehicle first stage went aboard the barge Poseidon

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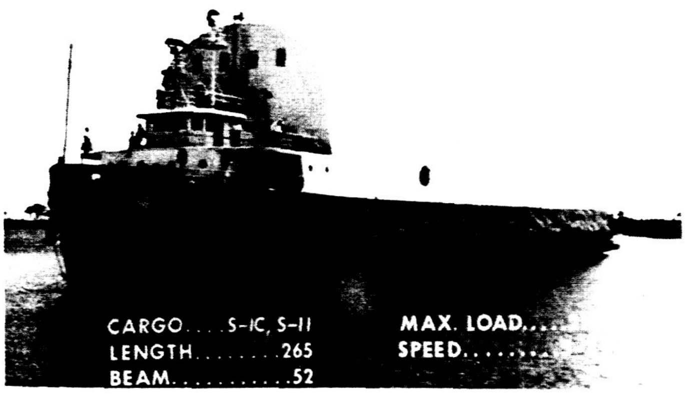

271. Barge Poseidon used to move Saturn stages

for shipment to KSC. On this same date NASA invited aerospace industries to propose definition studies of integrating experiment equipment in spacecraft that could be utilized for manned Apollo Applications missions. Two or more firms would be selected for negotiations of parallel nine-month study contracts.[280]

Workmen completed horizontal assembly of the second Saturn V first stage S-IC-2, on January 17, at MSFC's Manufacturing Engineering Laboratory,

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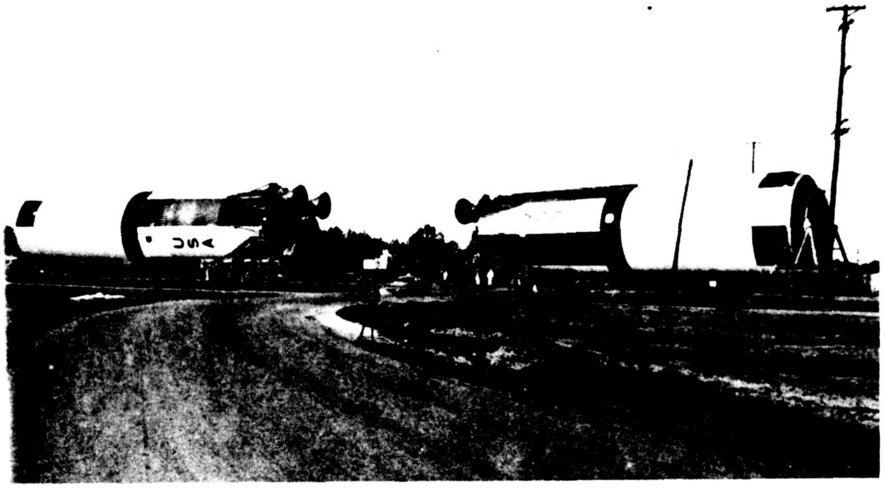

and the stage was moved to Quality Assurance Laboratory for post-manufacturing checkout. On this date technicians completed vibration testing of General Dynamics' S-IU-500V instrument unit. The unit went from Wyle Laboratories to the Manufacturing Engineering Laboratory for disassembly.[281]

Removal of the S-IC-T from the static test tower on January 20 at MSFC concluded the S-IC-T planned test program at Huntsville. MSFC moved the booster to Manufacturing Engineering building for storage and later conversion to the functional configuration of S-IC-4. NASA announced on January 20 that the hydrogen-fueled J-2 rocket engine had successfully completed a series of

272. S-IC-1 (right) and S-IC-2 (left) in transit at MSFC
273. S-IC-T removed from test stand at MSFC

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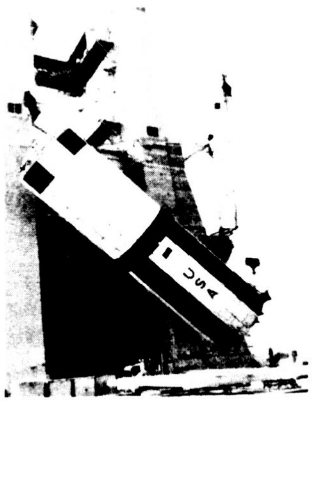

qualification tests to demonstrate performance over its design operating range. These qualification tests ended when a single engine operated successfully 30 times for a total firing time of 470 seconds. This accumulated duration was approximately eight times as long as the engine would be required to operate in flight.

A full-duration (2.5-minute) test for the fourth S-IB booster (S-IB-4) occurred at MSFC's East Test Area facility on January 21. Chrysler had conducted an earlier test of the engine, but for only 35 seconds.

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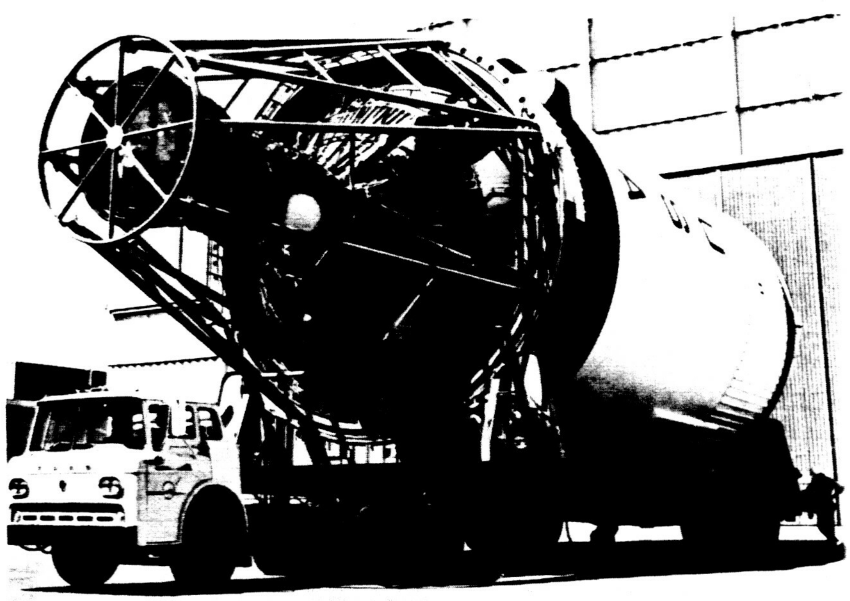
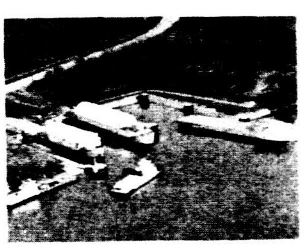


274. Moving of S-IVB-501 after post-manufacturing checkout

275. MSFC dock activity

275



Douglas personnel at Huntington Beach ended post-manufacturing checkout of the Saturn V S-IVB-501 third stage on January 28. Structural fabrication and assembly of the S-IU-501 ended at IBM Huntsville on this date. Early in 1966 MSFC formally redesignated the S-II all-systems stage (S-II-T) as the all-systems test/dynamics test stage (S-II-T/D).[282]

MSFC announced on February 2 that two S-IB flight boosters were aboard barges, one en route to the

Michoud Assembly Facility and the other one to the Kennedy Space Center. NASA's second Saturn IB flight booster S-IB-2 was due to arrive at KSC within a few days aboard the barge Promise. The first S-IB vehicle, AS-201, meanwhile, was awaiting launch at KSC.

Workmen at MTF completed integrated checkout of the GSE for S-II-T/D of February 3. [283]

Rehearsal countdown at KSC for the S-IB/Apollo mission was delayed 24 hours on February 5 because of "minor problems and resulting crew fatigue." NASA spokesman said that it was not yet known if the delay would affect the rescheduled February 22 launching. Meanwhile the S-IB stage for AS-202 arrived at KSC via barge where it was unloaded and transported to hanger AF for receiving inspection and installation of three fins.

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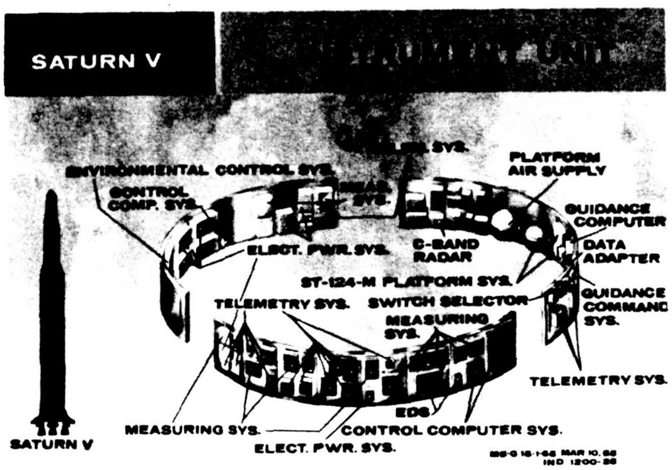

On February 14 the MSFC Quality and Reliability Assurance Laboratory completed, as scheduled, the checkout of S-IU-500FS, a ground version of the Saturn V instrument unit. [284]

MSFC continued to emphasize testing. It announced on February 15 that the first stage of the Saturn IB launch vehicle prior to its maiden flight had been "time tested" in more than 5000 single-

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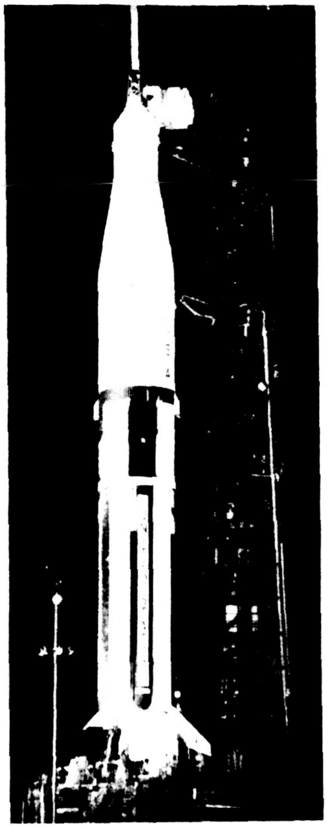


276. AS-201 awaits launching, KSC

277. Instrument unit configuration

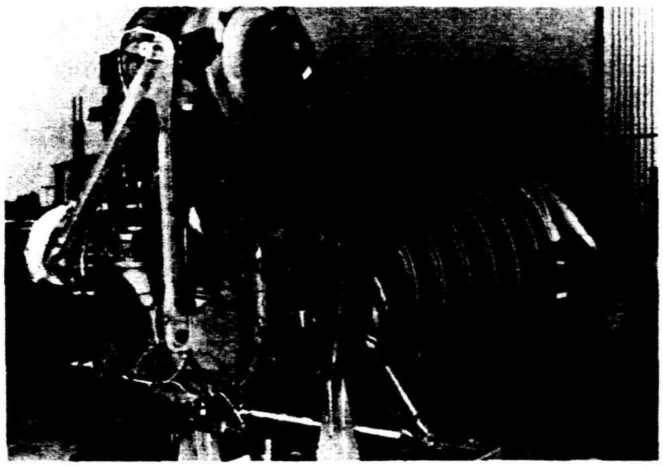
engine tests. In addition to these single engine tests of the H-1 rocket engines, there had been 72 vehicle tests.[285]

Technicians at MSFC successfully test-fired the S-IC-1 on February 17. The firing, lasting 40.7 seconds, met all the main test objectives.[286]

NASA's Saturn S-II facility stage (S-II-F) left Seal Beach, on February 20 for KSC aboard AKD Point Barrow. S-II-F, a nonflight version of the stage, would serve as second stage of the Saturn V facilities checkout vehicle, and would test and verify launch facilities, techniques, handling procedures, and operations. In a space hardware

278. *H-1 engine*
279. *Transfer of S-II-F and interstage from dock to VAB, KSC*

278



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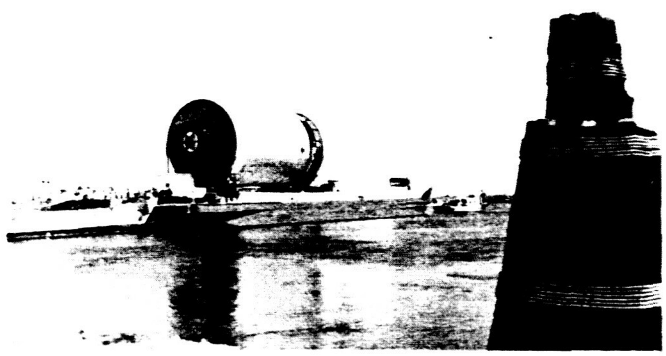

movement on the following day, the instrument unit for the second S-IB launch vehicle (S-IU-202) arrived at KSC from MSFC aboard the Promise. A booster for this S-IB was already at the KSC launch site.

On February 24 and 25 MSFC technicians continued captive-firing tests of the first stage Saturn V launch vehicle (S-IC-1). MSFC scheduled the February 25 static firing for 125 seconds but had to terminate it after 83.2 seconds when a red-line observer received an incorrect reading from a faulty transducer. However, MSFC scientists determined that in this second static firing in two days all criteria for the second S-IC-1 static firing were met and that no additional static firings were required.[287]

After postponement on three consecutive days because of continuing bad weather, NASA on February 26 launched with its Saturn vehicle, SA-201, the Apollo Spacecraft 009 payload from KSC Launch Complex 34. The vehicle performed throughout the powered and coast phases of flight. No major system malfunctions occurred in this unmanned suborbital Apollo flight. In lifting the spacecraft, SA-201's first stage had generated 1.6 million

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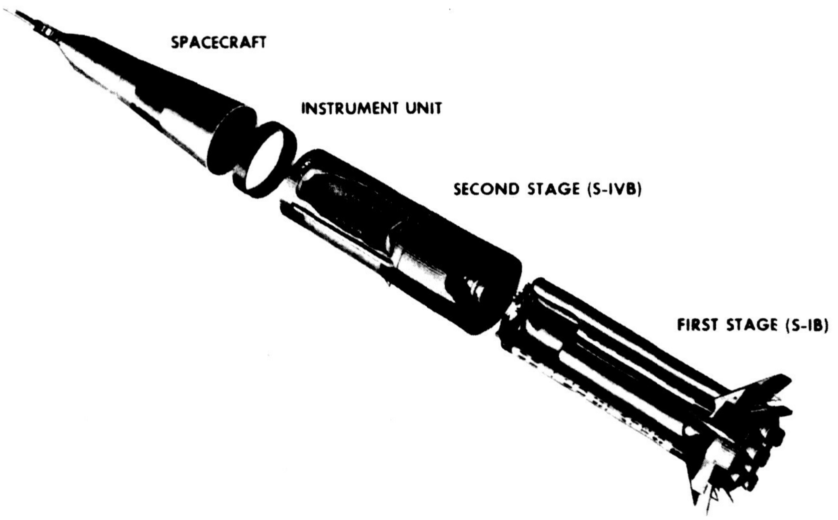

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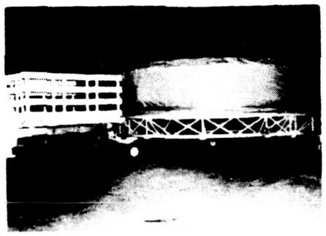

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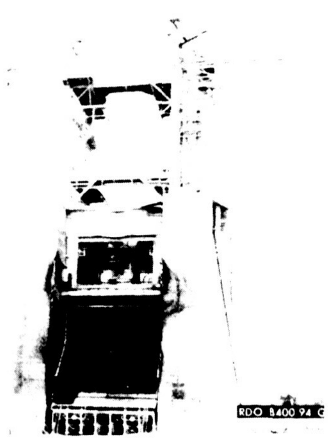

280. S-IU-202 moving to KSC
281. S-IC development test stand, Huntsville
282. AS-201 launch, KSC
283. Uprated Saturn I launch vehicle configuration

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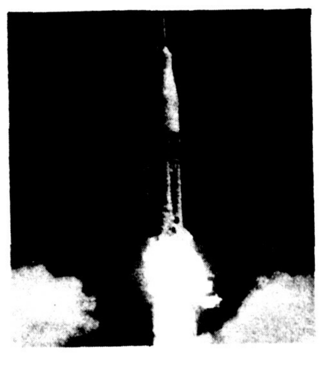

pounds of thrust. After burning 2 minutes and 26 seconds, propelling the Apollo to 37 miles altitude, the booster's eight H-1 engines, fueled with kerosene and LOX, shut down and the stage separated from the S-IVB. Four seconds later, a 200,000-pound thrust S-IVB (second) stage engine, burning liquid hydrogen and liquid oxygen, ignited.[288]

On February 28 at MSFC workmen moved the S-IB-5 into a static test stand in preparation for captive firings.

MSFC shipped the S-IU-500F to KSC on March 1. On this same date assembly of the S-IVB-503 and S-IVB-504 continued at Douglas in Huntington Beach, California, and workmen began factory checkout of the S-IVB-502.[289]

NASA signed with the Boeing Company a March 4 supplemental agreement converting the Saturn V first stage (S-IC) contract from a fixed fee to an incentive fee contract. It was the first Saturn stage contract to be converted to an incentive type. At the time of this conversion the Boeing contract was valued at $850, 114, 303.[290] Also on March 4 the S-II-F stage and its interstage arrived at Port Canaveral, Florida.

On March 10 MSFC shipped a Saturn V instrument unit (S-IU-500FS) aboard the Super Guppy aircraft to Huntington Beach, for testing with an S-IVB stage in a simulated space environment.

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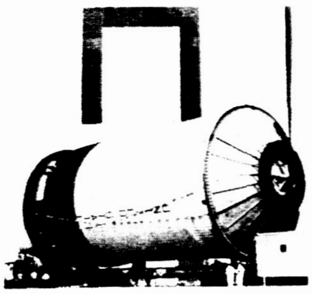

284. S-II-F stage arrival, KSC

285. S-IVB facilities at Huntington Beach

285

The following day the S-IVB-501 stage left Huntington Beach for Sacramento where it would undergo acceptance firing. Meanwhile at KSC workmen erected and mated the S-IVB stage and instrument unit of the AS-202.[291]

Douglas Aircraft Corporation successfully conducted a March 18 acceptance test of the fourth flight Saturn S-IVB-204 stage at its Sacramento Test Center. Technicians fired the stage for about 455 seconds.[292]

NASA announced March 24 that it would negotiate incentive contracts with two major aerospace firms for the procurement of five additional Saturn V first stages (S-IC) and 33 F-1 rocket engines. NASA would negotiate with the Boeing Company for the stages and with Rocketdyne for the F-1 engines for these stages. The five S-IC stages would cost in excess of $165 million. These contracts were in line with NASA's plan to launch 15 Apollo/Saturn V space vehicles by the end of 1970.[293]

Mating of the S-II-F with the S-IC-F stage occurred at KSC, March 28. On the following day workmen mated the S-IVB-500F with the S-II-F, and the day after they erected the S-IU-500F.

On March 30 the S-IVB-500-ST flew from California to MSFC aboard the Super Guppy.

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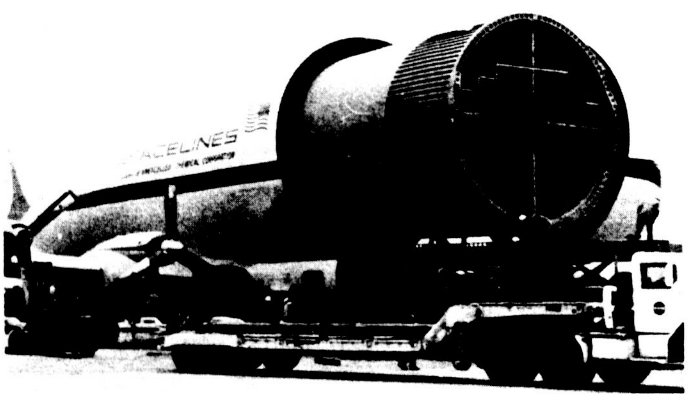

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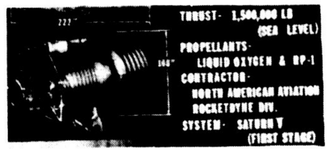

286. S-IVB facilities at SACTO
287. F-1 engine
288. S-IVB aboard Super Guppy

On March 31 there were major Saturn headlines at MSFC. Chrysler Corporation personnel captive fired the S-IB-5 for about 2.5 minutes, the second and longest duration firing for the booster.[294]

289. S-IB stage erection in test stand, Huntsville
290. J-2 production at Rocketdyne

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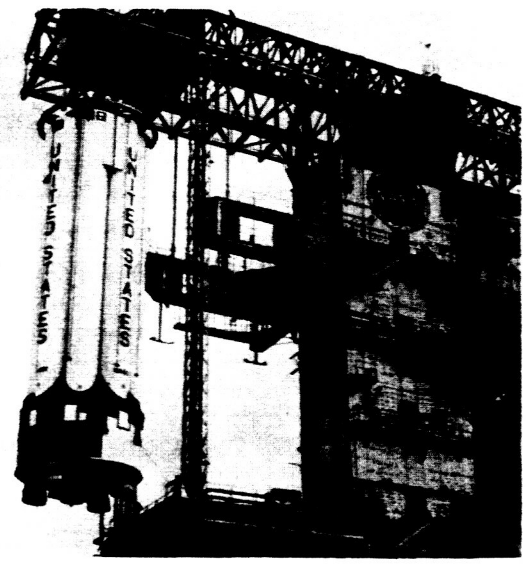

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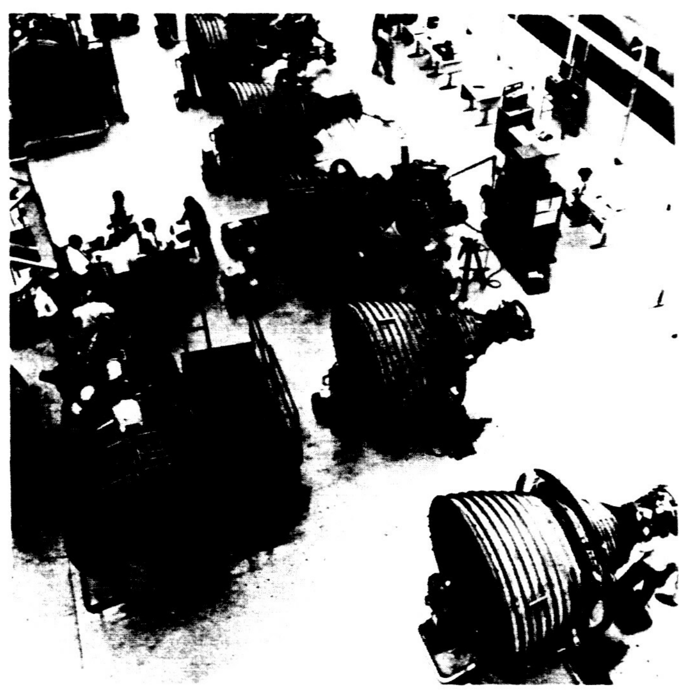

April 1 NASA announced that project management of its first hydrogen-fueled engine, the RL10, was being transferred to Lewis Research Center at Cleveland, Ohio. A cluster of six RL10 engines had powered the Saturn I's S-IV second stage before the conclusion of MSFC's Saturn I program the previous year.

In an April 4 release NASA announced a change in sequence of the S-IB-202 and the S-IB-203 launches. Uprated S-IB-202 was rescheduled to follow the AS-203 mission. The purpose of the sequence change was to provide additional time for checkout of Apollo spacecraft to be flown in the AS-202 mission. AS-203 was a launch vehicle development mission and would not carry an Apollo spacecraft.[295]

NASA announced on April 6 the purchase under a $7,634,742 modification to an existing contract of 22 additional H-1 engines for the S-IB launch vehicle. In addition to the engines the contract with North American Aviation's Rocketdyne Division called for three years of support services, including training, field engineering, and supply support.

The third S-IB booster (S-IB-3) departed Michoud for KSC on April 7. The S-IB stage for AS-203 arrived at KSC via barge Promise where it was

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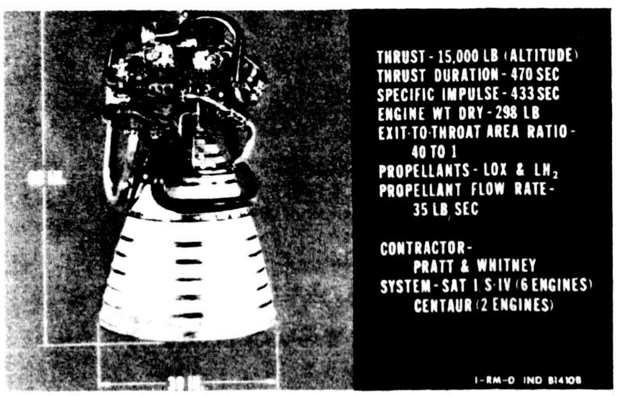

291. RL10 engine
292. Final check of H-1 engines before shipment
293. Barge Promise

292

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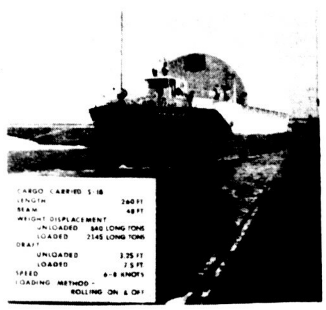

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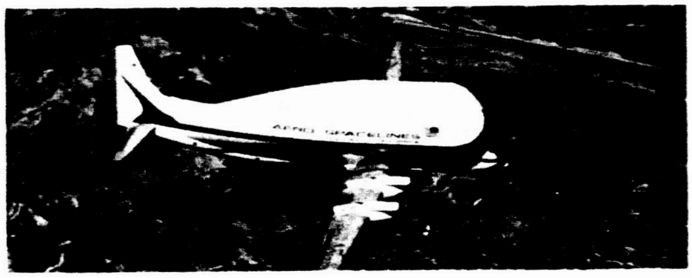


DIMENSIONS		SPECIFICATIONS (APPROXIMATE)	
WING SPAN	156 ft 3 in		
FUSELAGE LENGTH	141 ft 2 in	EMPTY WEIGHT	110,000 LBS
TAIL HEIGHT	46 ft 5 in	PAYLOAD (APPROXIMATELY)	45,000 LBS
FUSELAGE HEIGHT	36 ft 6 in	TAKEOFF WEIGHT (MAXIMUM)	175,000 LBS
CARGO COMP. (DIAMETER)	300 in	CRUISE SPEED	250 MPH
CARGO COMP. LENGTH	94 ft 6 in		
LENGTH CARGO COMP. 25 ft DIA.	30 ft 8 in		IND B20258

unloaded and moved into hangar AF on April 12. Six days later workmen erected the S-IB stage on Launch Complex 37B. Meanwhile, MSFC loaded the S-IB instrument unit for AS-203 aboard the Super Guppy for flight to KSC. As preparations continued for erecting AS-203, KSC technicians continued propellant tests of the nearby AS-202.

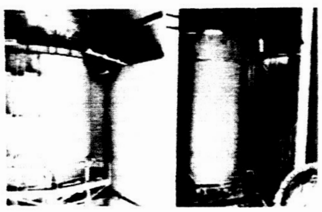
From April 19 to April 21 nine NASA astronauts visited MSFC for briefings on the S-IB-1 launch vehicles to be used in the initial manned Apollo missions. Briefing areas included tours, hardware descriptions, and design philosophy.[296]

MSFC announced on April 21 that NASA had awarded $50,000 60-day fixed-price contracts to Douglas Aircraft Company, McDonnell Aircraft Corporation, and Grumman Aircraft Engineering Corporation to perform definition and preliminary design studies and evaluate a plan to make spent Saturn V S-IVB stage hydrogen tanks habitable for manned space missions up to 30 days in duration. MSFC would manage the contracts.[297]

On April 23 workmen at MTF successfully captive-fired for 15 seconds S-II-T, the Saturn V second stage all-systems test vehicle. This was the first test of a flight-weight S-II stage. The stage, largest and most powerful liquid oxygen-liquid hydrogen stage known, developed one million

294. Super Guppy
***295.** S-IVB stage hydrogen tanks*
296. S-IVB stage in Test Stand Beta 1, SACTO

295



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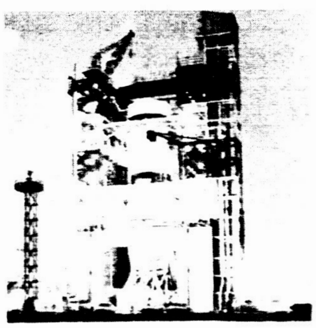

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pounds of thrust from its five J-2 engines. This test also marked the first operational use of MTF.

MSFC announced on May 6 that the first uprated J-2 rocket engine had arrived at MSFC from Rocketdyne. In uprating the J-2, Rocketdyne had increased the thrust for a new thrust capability of 230,000 pounds. NASA schedules called for use of the higher thrust J-2 in the second stage of the S-IB, beginning with vehicle AS-208 and, in the second and third stages of the Saturn V, beginning with vehicle AS-504.[298]

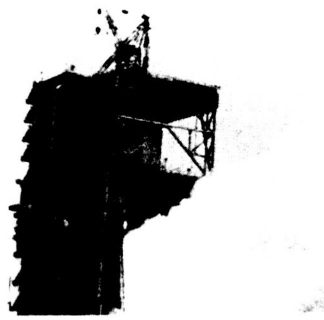
Technicians at SACTO Test Stand Beta 1 completed the S-IVB-501 integrated systems checkout on May 9.[299]

Helium-bottle trouble on May 10 resulted in termination of the second S-II-T firing at MTF. The following day, in a second attempt to complete a static firing of the S-II-T, the engine fired about 47 seconds. Premature cutoff occurred because of a gas generator problem.

A 154-second static firing of S-II-T, the all-systems version of Saturn V's second stage, occurred at MTF on May 17. This was a successful test of the nation's most powerful hydrogen-oxygen engine. Technicians made 1100 measurements and gimballed four of the five engines. These engines in flight would provide stability and control of the stage.[300]

297. S-II-T static firing at MTF
298. First duration firing of an S-II flight stage
299. Saturn V in movement at KSC

298



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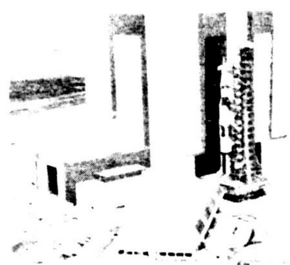

On May 19 MSFC announced the following nomenclature changes as recommended by NASA Headquarters Officials, Dr. Seamans, Dr. Mueller, and Mr. Scheer:

"Lunar Excursion Module to be called Lunar Module; the Saturn IB to become 'the Uprated Saturn I.' At first the changes will be noted as 'the Uprated Saturn, the Saturn IB' gradually dropping reference to the Saturn IB as the new name becomes more familiar. This would enable us to continue the string of Saturn I successes. Realistically the Uprated Saturn I is what we have anyway; in general public releases we should begin referring to Saturn stages simply as the first, second, or third stages, and, where helpful, to semi-technical press and in press kits follow with the technical nomenclature, i.e., 'the third stage of the Saturn V (S-IVB),' etc.; future releases and announcement should make use of the new nomenclature."

The first full-duration firing of the S-II flight stage occurred May 20 at MTF when S-II-T test-fired for 354.5 seconds. LOX cutoff sensors initiated cutoff automatically. The firing passed all major test objectives with the exception of the propellant utilization system. This was the fourth static firing of the S-II-T. The stage developed one million pounds of thrust from its five hydrogen-oxygen-powered J-2 engines.[301]

"Rollout" of the SA-500F occurred at KSC May 25. The 500,000-pound facility test vehicle, 365 feet long, moved from the Vehicle Assembly Building (VAB) on its 3000-ton diesel-powered steel-link crawler transporter to Pad A to verify launch facilities, train launch crews, and develop test checkout procedures. Also on May 25 technicians at MTF attempted the second full-duration firing of the S-II-T but terminated the firing after 198 seconds as a result of fire on engine No. 5. The fire burned an electrical cable to cause the cutoff. This was the fifth static firing of the S-II-T.[302]

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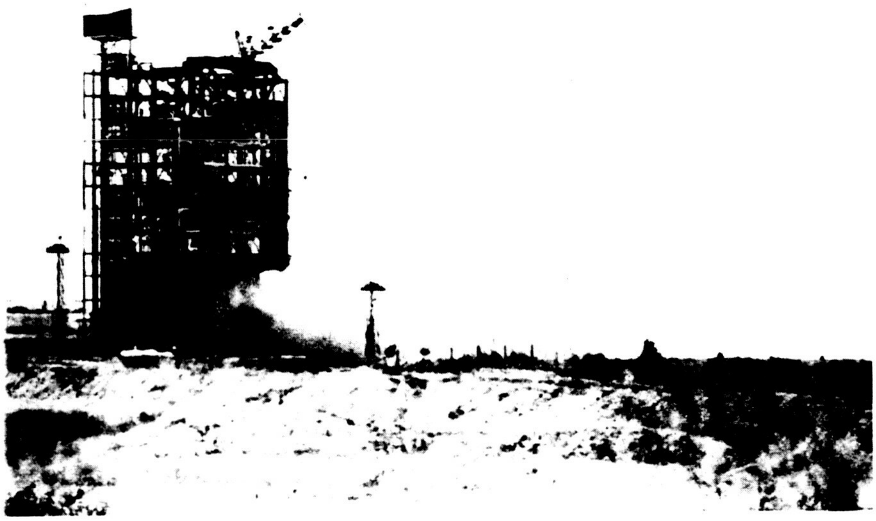


300. S-IVB-302 acceptance firing at SACTO

On May 26 at Sacramento Beta 1 test stand there was a second successful firing of S-IVB-501. This test of S-IVB-501 consisted of a 151-second mainstage first burn, a 106-minute simulated orbital coast period, and a 301-second mainstage burn after restart.[303]

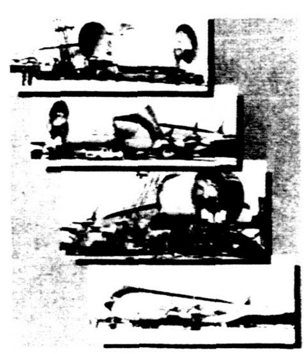
NASA announced on May 27 the selection of two firms for negotiations of parallel one-year study contracts for integration of experiments and experiments support equipment in space vehicles and spacecraft involving manned Apollo Applications missions. Estimated value of each contract was approximately $1 million.

A static test version of the Saturn V second stage S-II-T ruptured during pressure tests at MTF on May 28, and five North American Aviation technicians monitoring the test received minor injuries. The accident occurred when the hydrogen fuel tank of the one-million-pound thrust stage failed under pressure. S-II-T, which had five hydrogen-oxygen J-2 engines capable of generating one million pounds of thrust, had been tested

301. Destroyed S-II-T/D due to overpressurized liquid hydrogen tank
302. Loading sequence of Super Guppy
303. Saturn V and mobile launcher on crawler emerging from VAB, KSC

301

302



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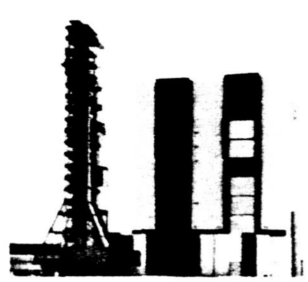

May 25 in ground firing but stopped firing after 195 seconds when a hydrogen link leak caused automatic cutoff. At time of the explosion, technicians were trying to determine cause for the hydrogen leak. No hydrogen was in the tank when the explosion occurred. Under the direction of MSFC, a Board of Inquiry headed by Dr. Kurt H. Debus, Director of Kennedy Space Center, convened on the night of May 28. Immediate investigation revealed that the seoond shift crew, not knowing that the liquid hydrogen pressure sensors and switches had been disconnected, had attempted to pressurize the tank. Believing that a liquid hydrogen vent valve was leaking, the technicians closed the facility by blocking valves. This had caused the vehicle tank to become over-pressurized and burst.[304]

On May 30 the board released its findings after two days of inquiry. The fuel tank of the S-II stage had been pressurized beyond design limits. There was a need for tighter controls over MTF test procedure.

On June 1 the Saturn V third stage (S-IVB-502) flew aboard the Super Guppy aircraft from the Huntington Beach to SACTO for static testing. A 33,000-pound stage, 59 feet long and 21.5 feet in diameter, this was the second Saturn V upper stage to arrive at the Douglas test site.

At Redstone Arsenal MSFC successfully static fired the second S-IC stage (S-IC-2) of the flight Saturn V launch vehicle for 126.3 seconds and recorded 1200 measurements of the stage's performance. The five F-1 engines, four of which were gimballed during this June 7 test, generated 7.5 million pounds of thrust.[305]

Because Hurricane Alma approached Kennedy Space Center on June 8, it was necessary to interrupt the processing and test activities of SA-500F and move the vehicle back to the VAB. The hurricane threat passed, and two days later the vehicle was again back on Pad A.[306]

On June 27 NASA announced the conversion of its contract with Douglas Aircraft Company for development of the Saturn's S-IVB stage to a CPIF agreement. Under the revised contract, the company's fee would be increased or decreased depending upon attainment of the incentive for cost, schedule, and performance. The original contract was a CPFF arrangement. Estimated cost of the total effort under both portions of the contract was about $700 million plus fee. To date about $595 million had been funded.

On June 29 MSFC captive fired both an uprated Saturn I first stage and an F-1 engine at Redstone Arsenal. At MSFC's East Test Area technicians fired for a full duration the sixth flight Saturn booster (S-IB-6). It had previously been tested for 35 seconds on June 22. At the West Test Area MSFC technicians captive fired the F-1 engine on a first run for about 40 seconds. The S-IB, powered by eight Rocketdyne H-1 engines, produced 1.6 million pounds of thrust.[307]

Following the destruction of S-II-T during a test at MTF, NASA extended the S-II battleship program until July of 1967. Also during June there were changes in the launch schedule for the Apollo/Saturn 203 launch. Previously scheduled for June 30, NASA rescheduled it for June 29 because of the scheduled launch of a lunar-anchored interplanetary monitoring platform Explorer. But by June 29 NASA had rescheduled SA-203 launch because of electrical problems, so that it would come no earlier than July 5.

At Kennedy Space Center technicians on July 2, 1966, erected and mated the AS-202 spacecraft. Three days later the twelfth Saturn vehicle, AS-203, flew from KSC Launch Complex 37B. After one hour, 53 minutes, and 17 seconds of countdown holds, the vehicle lifted off the pad to begin the second unmanned flight of the uprated Saturn I. The vehicle's second stage (S-IVB), instrument unit, and nosecone, weighing 58,500 pounds, com-

304. AS-203 in flight, showing shock wave forming around nose cone

304

prised the heaviest U. S. satellite ever placed in orbit. Primary mission of this July 5 flight was an engineering study of liquid hydrogen fuel behavior during orbit.[308,309]

MSFC technicians installed the S-IC-T stage in the S-IC test stand at Redstone Arsenal on July 7. Tentative plans called for static firings, including fuel and LOX loading tests,[310]

On July 8 NASA announced the award of a contract to Federal Electric Corporation (FEC) of International Telephone and Telegraph Corporation for technical support of the Saturn launch vehicle reliability program at MSFC. The cost-plus-award-fee contract would be for one year at an estimated cost of $1.8 million, with a provision for two additional one-year periods. The FEC would perform test program analysis, failure mode and effects analysis, hardware and software failure analysis, and maintainability in human engineering analysis for MSFC's Quality and Reliability Assurance Laboratory. Most of the work would be in Huntsville.[311]

Acceptance firing of the S-IVB-502 stage occurred at Sacramento, California, on July 28. The captive firing, conducted by Douglas Aircraft Company, prime contractor, simulated the operation of the propulsion system during the burn portion of the flight. The stage burned 150 seconds, shut down for one and one-half hour simulated coast period, and then reignited and operated 291 seconds. Such performance would be required in lunar missions. A J-2 hydrogen-oxygen engine made by Rocketdyne Division of North American Aviation Company powered the stage.[312]

NASA Headquarters unconditionally approved J-2 engine program contract NAS8-19 on July 29. This contract established the provision for production support effort through December 1968, and for delivery of the 155 J-2 engines required for the Apollo program. The contract combined what had been two major J-2 contracts.[313] Also on

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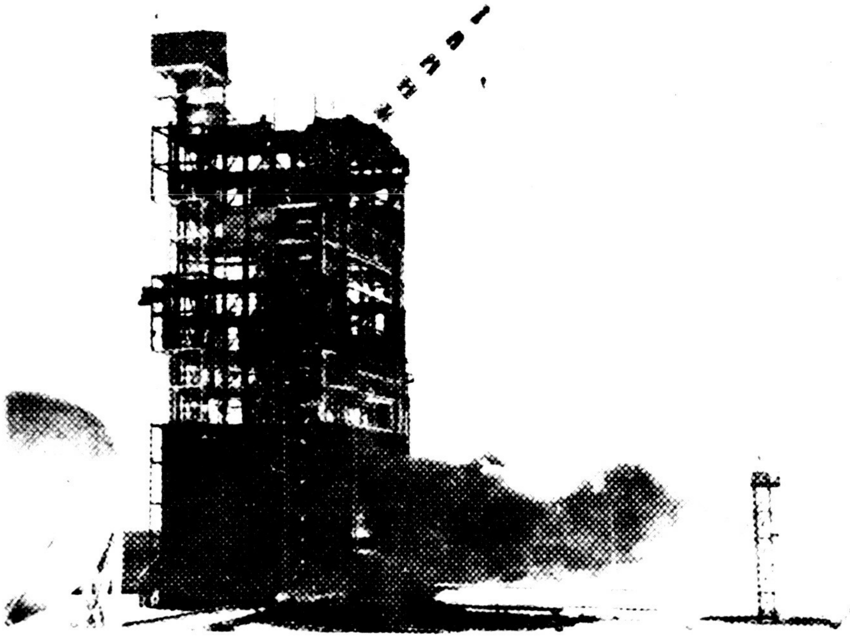

305. Acceptance firing of the S-IVB-502 at Sacramento

July 29, technicians at Seal Beach made hydrostatic tests of the S-II-3 stage for SA-503. And at Santa Susana technicians conducted a 40-second mainstage test of the S-II battleship stage. Automatic cutoff initiated from engine number 5, but data revealed that cutoff occurred erroneously.

S-II-1, the first flight S-II stage scheduled for static firing at MTF, left Seal Beach on July 31.

NASA announced on August 1 the signing of a $339 million supplemental agreement with Chrysler Corporation's Space Division which increased the contract value by $14 million and converted the uprated Saturn I first stage production contract from a CPFF to a CPIF contract. The contract, to continue through February 1969, would involve Chrysler's assumption of design responsibility and implementation of a total qualification and reliability testing plan. Under this contract managed by MSFC, Chrysler would manufacture, assemble, and test 12 stages.[314]

MSFC announced on August 5 the award of a $23.4

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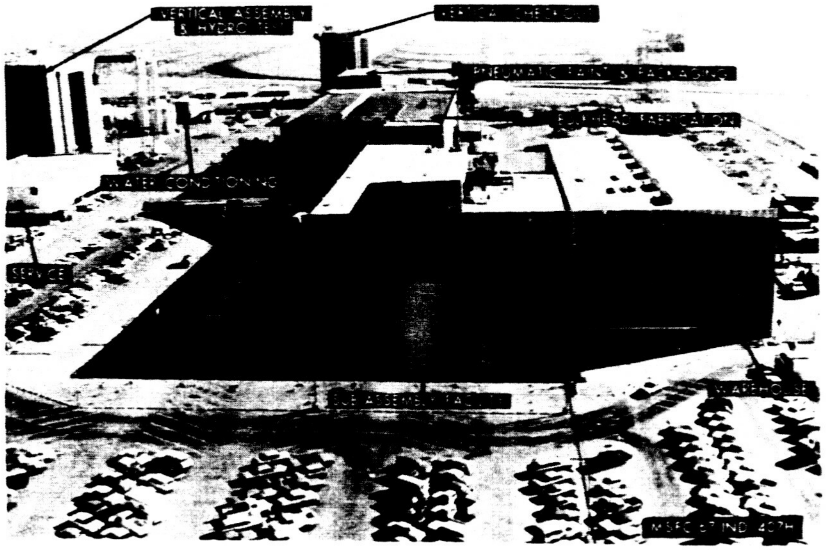

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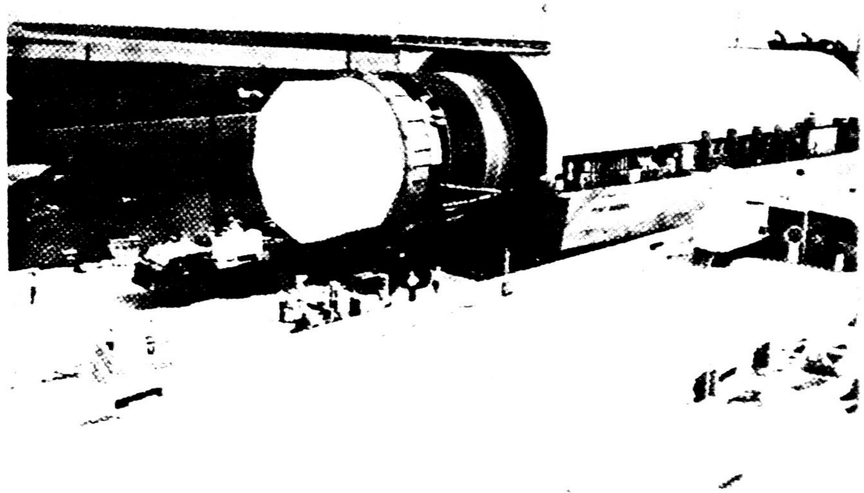

306. S-II facilities at Seal Beach

307. Transfer of the S-II-1 from the Point Barrow to the Pearl River at Michoud en route to MTF from Seal Beach

million modification to an existing contract with North American Aviation Space and Information Systems Division for additional work in building and testing the Saturn V launch vehicle's second stage. The contract modification included several engineering changes, many of which were already completed or under way.

NASA decided to change the Sacramento-to-KSC shipping date of the S-IVB-501 from August 2 to August 12. This would meet the KSC required date and allow additional time for closeout of all open work prior to shipment. Stage turnover to NASA came in a ceremony at Sacramento on August 9. On August 11 technicians completed installation of flight vehicle instrumentation and tank purge operations. The stage then went aboard the Super Guppy aircraft and departed Sacramento on August 12, as scheduled, arriving at KSC on August 14, after a one-day delay because of weather. At KSC the stage went into the VAB low bay where receiving inspection began immediately.[315]

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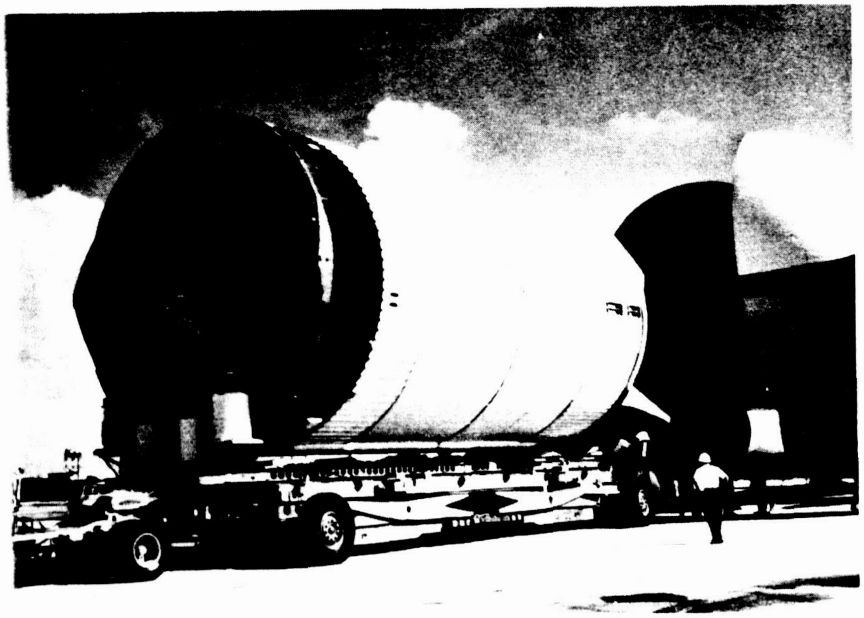

308. General view of S-IVB-501 aboard Super Guppy

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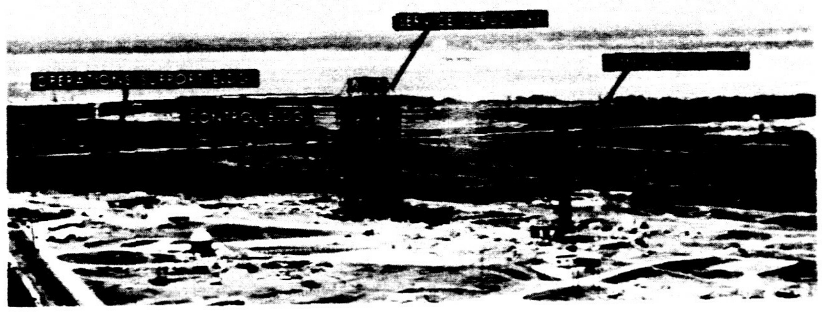

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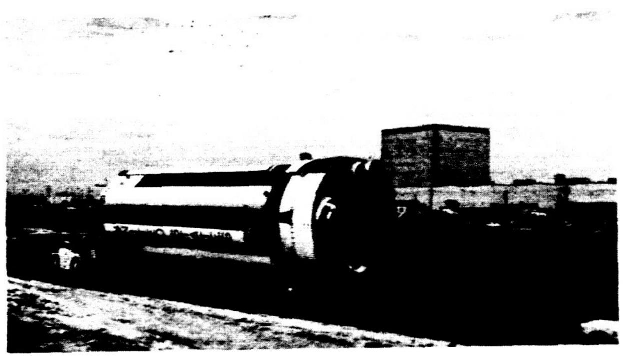

309. Complex 34, Launch KSC

310. Fourth Uprated Saturn I, S-IB-4, in first stage of journey to KSC

NASA announced on August 10, 1966, the rescheduling of the Apollo/Uprated Saturn I (AS-202) from August 20 to August 22. During checkout operations technicians had discovered leaks in liquid hydrogen fuel line fittings leading to the three fuel cells in the spacecraft service module. The fuel cells would supply electrical power to the spacecraft during flight. Later, NASA decided to fly the mission with the two remaining fuel cells which were capable of providing sufficient power for the one and one-half hour suborbital flight. AS-202 would fly from Launch Complex 34 at KSC.[316]

The fourth Uprated Saturn I (S-IB-4), the first scheduled to launch a manned Apollo spacecraft, departed Michoud for KSC, on August 10.

NASA announced on August 11 that MSFC would begin negotiations with the Chrysler Corporation and Douglas Aircraft Company for procurement of long-lead-time items for additional Uprated Saturn I launch vehicles. Cost of the long-lead-time items was estimated at $5 million to $10 million.

The first flight model (S-II-1) of the Saturn V vehicle's second stage arrived August 13 at MTF completing its 4000-mile voyage from Seal Beach. Workmen immediately moved the stage into the S-II stage service and checkout building for inspection and preparation for static firing.

On August 19 NASA selected McDonnell Aircraft Corporation of St. Louis, Missouri, for negotiations toward a fixed-price contract estimated at $9 million to provide an S-IVB airlock. The airlock would permit astronauts access to the empty hydrogen tank of spent uprated Saturn I second stages.

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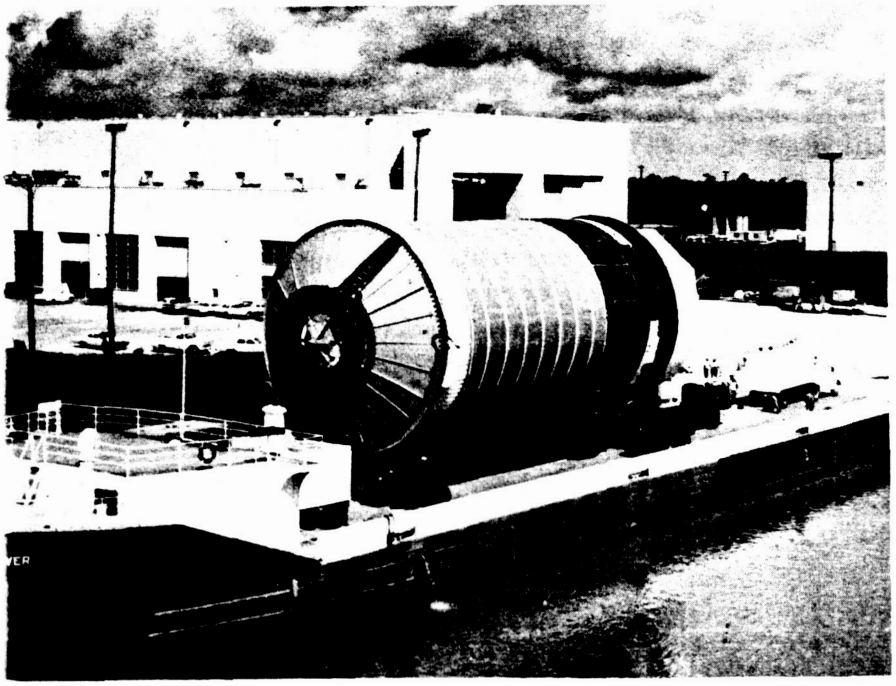

311. S-II-1 arriving at MTF for acceptance testing

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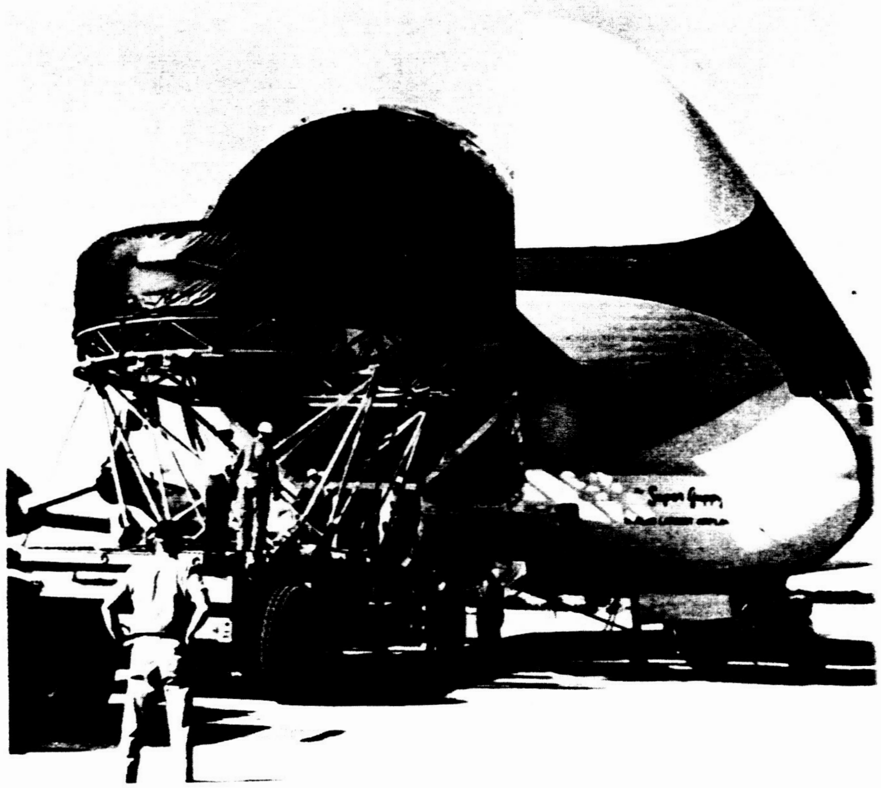
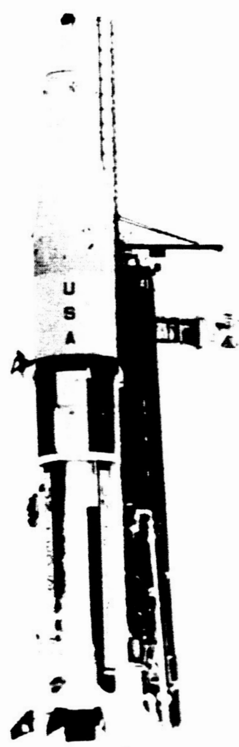


312. IU-501 arrives at KSC aboard Supper Guppy
313. AS-202 rises from KSC on August 25, 1966

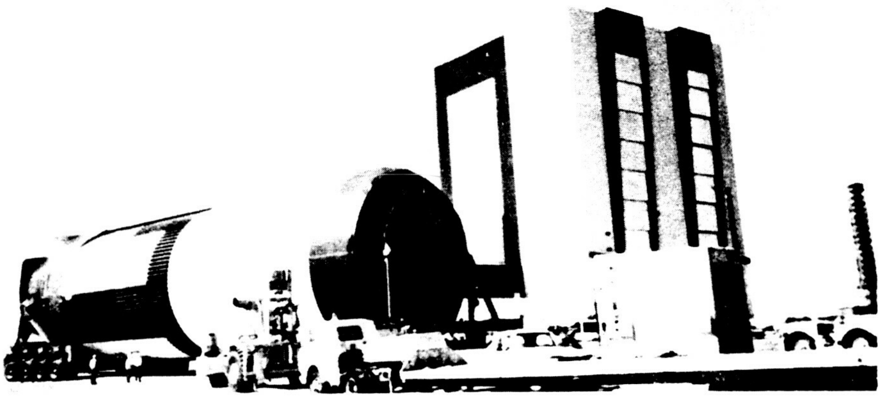
313



A LOX line leading to the Saturn V launch pad at KSC ruptured on August 19, spilling more than 800,000 gallons of LOX. The incident occurred during the first-stage tanking test when the pipeline ruptured spilling the 800,000 gallons of LOX; vacuum created inside the tank had caused a depression in the tank's 2.5-inch-thick dome.[317]

The S-IU-501 arrived at KSC on August 24. Apollo/Saturn vehicle AS-202, the third vehicle to fly in the Uprated Saturn I series, rose from Launch Complex 34 at Cape Kennedy on August 25. AS-202 was the thirteenth Saturn vehicle in a row to fly successfully through space. This was the second successful flight test of the Apollo spacecraft command and service modules before earth orbital manned missions. The flight proved the Apollo command module ablative heat shield by subjecting it to extended high heat loads during

314



314. S-IC-1 stage arrival, KSC

On August 26 MSFC shipped the first Saturn V flight booster (S-IC-1), scheduled to be launched early in 1967, to the Kennedy Space Center via the barge Poseidon.

NASA announced on August 28 that the August 19 rupture of the 900,000 gallon stainless steel storage tank for the Saturn V booster's LOX would delay the booster's first flight, scheduled for the first quarter of 1967, by at least 45 days.[320]

MSFC announced on September 7 that four barges carrying 400,000 gallons of vitally needed liquid oxygen were en route to KSC after being dispatched from the MTF. The shipment, together with 40,000 gallons brought into KSC by truck and rail tank cars, would replenish the liquid oxygen lost on August 19 when a line ruptured below the LOX storage tank serving Saturn V's Launch Complex 39. Schedules called for propellant loading tests to resume September 20, 1966.

The S-IC-1 arrived at KSC on September 11. Chrysler personnel at the Test Laboratory in Huntsville captive fired the seventh Uprated Saturn I flight booster for its full two and one-half minute test on September 13. After this successful test, schedules called for MSFC to return the booster to Michoud for post-static test checks.

Chrysler Corporation built the stage at the New Orleans facility.[321]

Last of the S-IVB-503 factory checkout tests occurred at Huntington Beach on September 14. The following day at MSFC's P&VE Laboratory in Huntsville technicians completed all test conditions for the S-IU-200S/500S-3 structural test unit. The final test condition for the unit was the application of a 140 percent maximum limit compression load on part of the unit.[322]

On September 23 the first Saturn V flight booster built at MAF (S-IC-3) departed aboard the barge Poseidon for MSFC to undergo static firing tests. According to plans technicians would later static-fire the boosters at MTF.[323]

MSFC announced on September 29 that it had awarded three new study contracts totalling $400,000 to investigate the launch vehicle needs and best methods for sending manned spacecraft on planetary flyby trips; North American Aviation, Inc., received $100,000 to study feasibility of modifying the Saturn V second stage, S-II, for use as an orbital ejection stage; Douglas Aircraft Company received $100,000 to study the feasibility of using Saturn V third stage, S-IVB, as part of a planetary vehicle; and TRW Systems, Inc., received $200,000 for study of alternate mission modes for manned Mars and Venus orbital and landing missions.[324]

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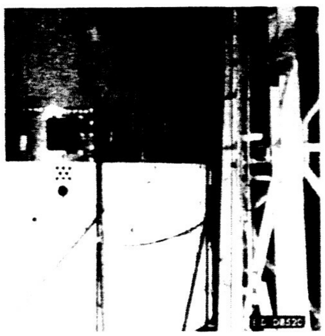

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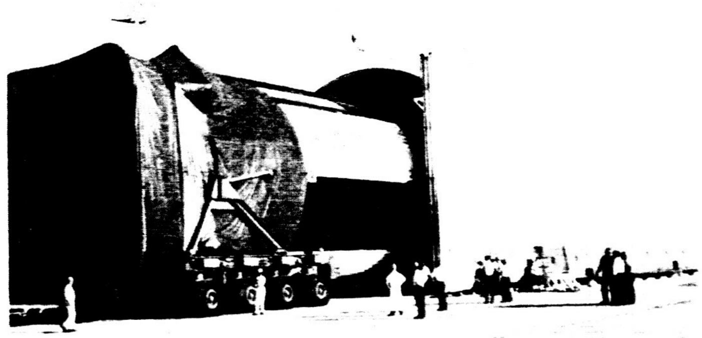

315. S-IU-200S/500S during structural test, MSFC

316. S-IC-3 being loaded on barge Poseidon for shipment to MSFC

After successful completion of post-manufacturing checkout at the Michoud Booster Checkout Facility, the S-IC-3 stage left Michoud on September 23 and arrived at MSFC on October 1. Unloading operations began on October 3, and on that same date workmen erected the stage in the test stand.[325]

The S-IVB-503 stage went from Los Alamitos to Sacramento via the Super Guppy aircraft on October 11. The stage moved to the Vertical Checkout Laboratory on October 12, and into the test stand on October 14. The SA-500F vehicle arrived at KSC on October 15.

On October 17 MSFC shipped its S-IC all-system test booster, S-IC-T, to MTF for use in checkout of a static test stand and for use in static firings. Workmen loaded the huge booster aboard the barge Poseidon for the 1000-mile river journey. Six days later the S-IC-T reached MTF. Meanwhile on October 25, after leaving Michoud a week earlier, the eighth Uprated Saturn I first stage (S-IB-8) reached the MSFC dock for static firing at MSFC by Chrysler Corporation personnel. Also at MSFC on October 25, NASA awarded the University of Wisconsin a $679,101 contract to develop sensors for a galactic X-ray mapping experiment to be flown on an Uprated Saturn I launch vehicle in 1968. The sensors would explore X-ray sources other than the sun and Crab Nebula.

317. S-IC-3 being erected in the static test stand at MSFC

317

NASA announced on October 26 the award to North American Aviation of a $37 million contract supplement for launch preparation and checkout of ten Saturn V second stages (S-II). Two days later NASA awarded a $4.5 million contract modification calling for the Boeing Company to assume design and procurement responsiblities for certain structural components and instrumentation of Saturn V first stages built at Michoud. The components, previously provided by the Government, included propellant ducts and valves and pressurization switches and gauges.[326]

On November 2 KSC workmen stacked the S-IU-

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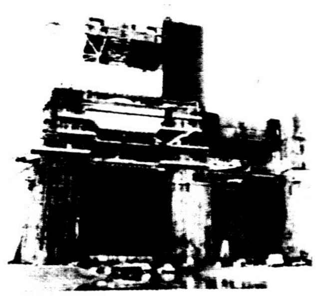
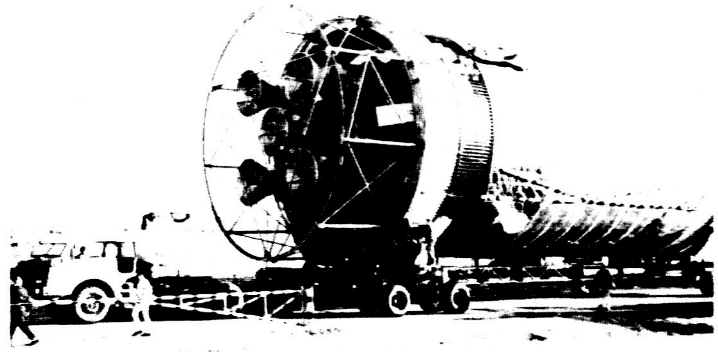


318. Buildup of the SA-501 vehicle using the H7-17 fit-up fixture as a spacer to replace the S-II-1 at KSC
319. S-II-F stage being unloaded at MSFC
320. S-IC test stand at MTF

319



501. The following day technicians at MSFC completed systems checkout of the S-IU-502. [327]

The S-II-F/D stage arrived at MSFC on November 10.

Technicians at MSFC successfully acceptance-fired the S-IC-3 on November 15 for 121.7 seconds mainstage. This was the last planned firing of the S-IC stage at MSFC. Future firings would be accomplished at the B-2 stand at MTF. [328] On November 16 at MSFC technicians sucessfully static fired the eighth Uprated Saturn I booster for 35 seconds. [329]

On November 17 NASA announced several Apollo/Saturn manned space flight schedule changes because of launch vehicle and spacecraft development problems. The principal change called for rescheduling a manned earth orbital mission, Apollo/Saturn 205, which was to have followed the first manned Apollo flight, AS-204. [330]

On November 18 NASA approved F-1 engine contract NAS8-18734 CPIF. This contract provided for 30 F-1 engines needed in the Apollo program and continued production support and GSE through June 1970. These 30 F-1 rocket engines furnished by Rocketdyne Division of North American Aviation would complete the number of engines (106) required by the 15 scheduled Saturn V vehicles, plus spares. The cost would be about $141 million.

The delivery of 30 engines would begin in November, 1967, and continue through October 1968.[331]

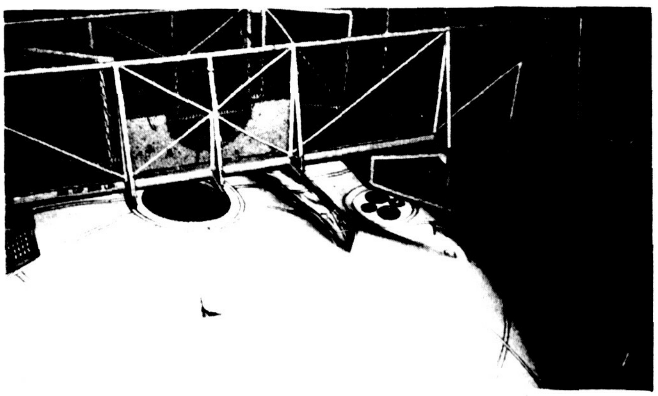
On November 29 a forward bulkhead of the liquid hydrogen tank for the S-II-3 flight stage suffered damage while the stage was in the horizontal position. The damage occurred at North American Aviation's Seal Beach Plant as workmen were removing a work ladder from the tankage interior. The stage was in position when a 10-foot section of the ladder dropped, striking the forward bulkhead and causing cracks. The fall resulted from a weld failure in the ladder retracting mechanism. NASA anticipated no impact on the S-II-3 delivery date.[332]

Technicians at MSFC on November 30 static fired the eighth Uprated Saturn I booster successfully in its second test for 145 seconds. The first stage performed as expected, developing 1.6 million pounds of thrust.[333]

At MTF on December 1 North American Aviation conducted a successful 384-second captive firing of the first flight hydrogen-fueled engines, developing a total one million pounds of thrust. During the test, number 2 and 4 engine SLAM arms did not drop, resulting in the successful gimballing of engines 1 and 3 only. The test included the recording of about 800 measurements of the stage's

321

322



321. F-1 engine checkout
322. Cracks in the liquid hydrogen tanks for the S-II-3

323

323. Dynamic vehicle stacked in the Saturn V Dynamic Test Tower at MSFC

performance, including propellant tank temperatures, engine temperatures, propellant flow rates, and vibrations.[334]

Workmen at MSFC completed stacking of the SA-500D vehicle on December 3.

Factory checkout of the S-IVB-504 flight stage ended on December 9 at Huntington Beach.

On December 13 a two-stage Uprated Saturn I launch vehicle was shipped to KSC. NASA would launch the vehicle in 1967 in an unmanned flight of the Apollo spacecraft lunar module. The booster stage, S-IB-6, for the AS-206 left Michoud near New Orleans on this date aboard the barge Palaemon. The Palaemon would deliver its cargo to KSC on December 19. The second stage, S-IVB-6, went aboard the Super Guppy aircraft at Mather Air Force Base. Douglas built the S-IVB stage, at Huntington Beach, California, and tested it at SACTO. Schedules called for the vehicle's instrument unit to fly on December 19 from MSFC to KSC aboard the Super Guppy.[335]

An all-systems test version of Apollo/Saturn V first stage, S-IC-T, went into the B-2 test stand at the Mississippi Test Facility on December 17. Stage electrical and mechanical hook-up to the test stand began immediately. Static firing would occur in early 1967 to demonstrate the facility checkout system.

MSFC announced on December 20 the award of a $7.2 million contract modification to Chrysler Corporation to begin procurement of long-lead-time items for additional Uprated Saturn first stages (S-IB). Under this agreement to be completed by June 30, 1967, Chrysler would procure the materials, components, and engineering support necessary to maintain its capability to assemble four Uprated Saturn I boosters per year. Chrysler was currently under contract to assemble and test 12 of the 1.6 million-pound first stages at Michoud.[337]

MSFC announced on December 28 that NASA had signed a $6,383,720 contract modification with the Missile and Space Systems Division of Douglas Aircraft Company for long-lead-time items for the upper stages of Uprated Saturn I vehicles. The contract, to be managed by MSFC, was extended through June 1967. The object of the procurement action was to maintain the option of ordering additional S-IVB stages for the Uprated Saturn I in the future, without suffering a delay in certain areas where considerable time might be required for material acquisition and/or manufacturing.

On December 30, 1966, MSFC technicians at the MTF test stand conducted a static firing of the first flight version of the Saturn V second stage, S-II-1. This second test firing, like an earlier firing, lasted more than six minutes. Normal procedure called for the stage to undergo post-static firing inspection or checkout next at the test site before being moved to KSC, but in a change of procedure MSFC began preparations at once to ship the stage to KSC for these checks. Project officials hoped to gain seven or eight days by performing much of the checkout and modification work at KSC.[338]

324. S-II-1 static firing at MTF

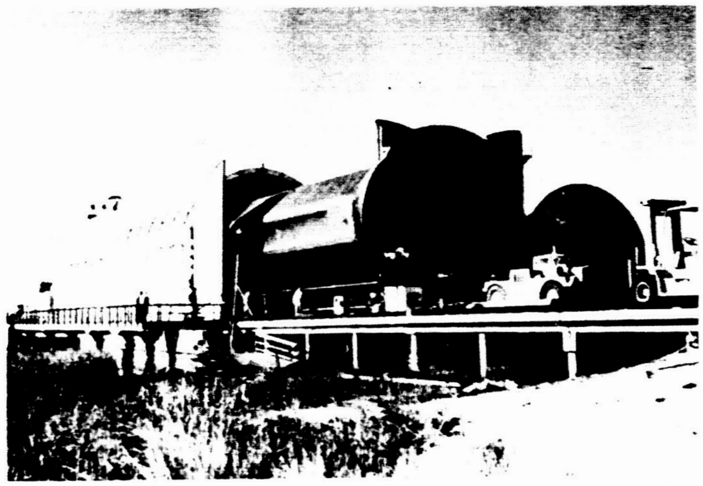
324

A successful S-IVB-208 stage acceptance firing occurred at Sacramento on January 12. Mainstage duration was 424.3 seconds, with automatic cutoff initiated because of fuel depletion. All test objectives were achieved.

The first flight version of a rocket stage to undergo captive firings at the Mississippi Test Facility, the S-II-1 stage of the Apollo/Saturn V, left Bay St. Louis, Mississippi, on January 16 enroute to KSC, it would become a part of the first Saturn V flight vehicle, scheduled for launch during the second quarter of 1967.[339]

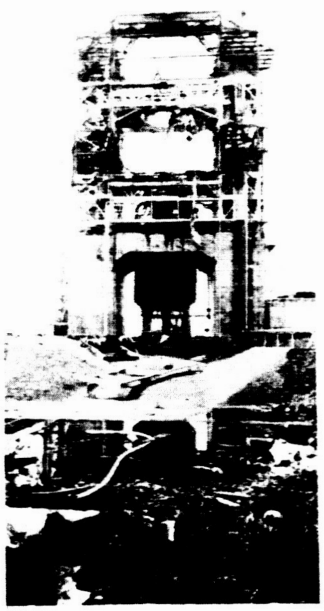
On January 20, 1967, the Saturn V third stage, S-IVB-503, exploded ten minutes before it was

325



325. S-II-3 at MTF aboard the Poseidon
326. S-IVB-503 after explosion in Test Stand Beta III at SACTO

326



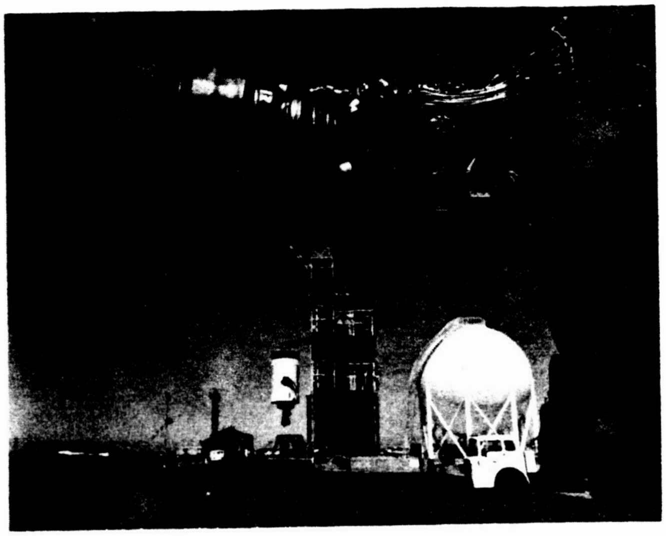
scheduled to be ignited in a test at Douglas Aircraft Company's SACTO. The explosion completely destroyed the stage at Test Stand Beta III. Post-accident investigation revealed that the ambient helium sphere weld was commercially pure Ti-55A titanium, not the specified Ti-6A1-4V titanium.[340]

At MSFC's ME Lab technicians completed a device to adapt the S-IC test stand to receive stages other than the S-IC. This S-IC test stand adapter consisted of approximately 90,000 pounds of welded stainless steel approximately 33 feet in diameter and 6 feet in height.

The S-II-1 stage arrived on the dock at KSC on January 21. Already stacked in the VAB at KSC were the SA-501 flight vehicle sections S-IC-1, S-IVB, and S-IU-501.[341]

A board to investigate the destruction of S-IVB-503 was organized at the Sacramento Test Center on January 23. Board members included Dr. Kurt Debus, Chairman; Karl Heimburg, MSFC Test Laboratory Director; and T. J. Gordon, Douglas Aircraft representative. On this same date KSC technicians erected S-IVB-206 stage on Launch Complex 37. Stage subsystem checkout began promptly in preparation for the first integrated

327



tests of the Uprated Saturn (IB) 206 vehicle.[342]

The S-IVB -504 stage (now designated S-IVB-503 as a result of the explosion of 503) arrived at SACTO January 25 where workmen installed it on Test Stand Beta I.[343]

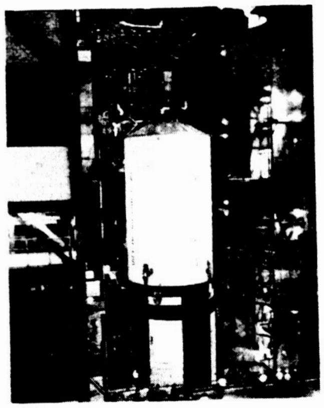
The ninth Uprated Saturn I booster to be assembled at Michoud arrived at MSFC on January 26 aboard the barge Palaemon. After captive firing at MSFC, S-IB-9 would, according to schedule, return to Michoud for post-firing checkout before shipment to the KSC launch site. On this same date workmen completed liquid hydrogen tank inspection of the S-II-1 stage positioned in the VAB at KSC. In California workmen completed pre-static checkout of S-IVB-209 and readied the stage for airlift to SACTO.[344]

The three-man crew for NASA's first manned Apollo space flight (AS-204) died, apparently instantly, when flash fire on January 27 swept their Apollo I spacecraft mated to the Uprated Saturn 204 vehicle. This accident, killing Virgil I. Grissom, Edward H. White II, and Roger B. Chaffee, was the worst in the history of the U. S. space program. It occurred at KSC's Launch

327. S-IV B-504 being installed in Test Stand Beta I; S-IV B-209 on transporter in foreground

328. S-II in VAB

328



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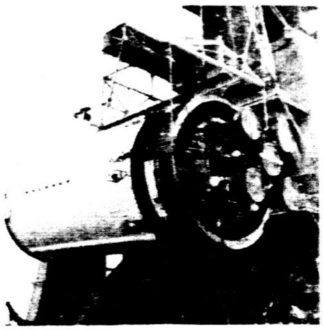


330

329. S-II-2 flight stage erection at MTF
330. Erection of AS-501 at KSC

Complex 34 during the first major rehearsal for the February 21 mission.

On January 27, 1967, the S-II-2 stage left Seal Beach, to pass through the Panama Canal and on to MTF. After its 4800-mile journey lasting sixteen days, the S-II would arrive at MTF for two static tests. At SACTO on this historic date workmen completed installation of the S-IVB-503 stage on the Beta I test stand.

On February 3 NASA signed an incentive contract with the Boeing Company for five additional Saturn V first stages. As a result of this contract, Boeing was now under contract to fabricate and assemble 15 of the 7.5 million-pound thrust boosters, thereby completing the S-IC stage requirements for the previously announced scheduled launching of 15 Saturn V space vehicles in the Apollo manned lunar landing program. The $120 million supplemental agreement awarded by MSFC extended the Boeing contract through June, 1970. This modification increased the total estimated value of the Boeing contract to $977 million.[345]

The S-II-2 stage arrived on the dock at MTF on February 11. The S-II-2 stage, part of the second Saturn V vehicle (SA-502) scheduled for launch from KSC late in 1967, was scheduled for testing at MTF late in March.[346]

On February 18 workmen erected the S-II-2 stage in the A-2 test stand at MTF.

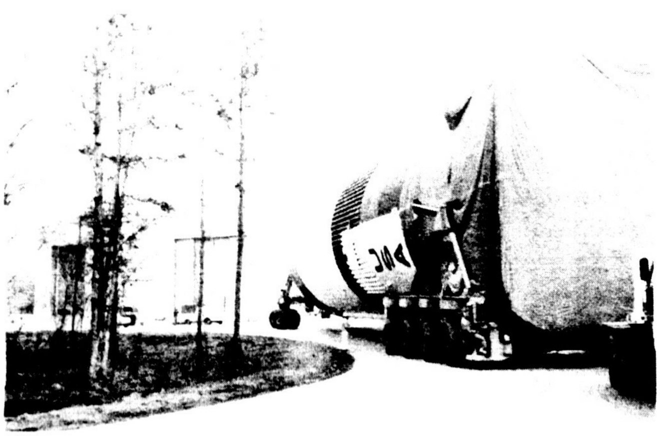
After completion of J-2 engine installation, stage checkout of S-IVB-505 began at Huntington Beach on February 20. A day later the S-IVB-502 left SACTO for KSC.

Erection of the AS-501 stages at KSC began on February 23 and was completed with the stacking of the IU on February 25. Schedules called for the launch vehicle "power on" to begin three days later.[347]

MSFC personnel static fired the Uprated Saturn (S-IB-9) first stage at Huntsville for approximately 35 seconds on February 28.[348]

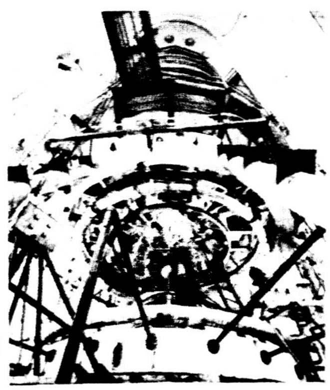
The second Saturn V launch vehicle flight booster, S-IC-2, left MSFC for KSC by barge on March 3. Meanwhile, during March two Saturn boosters riding side by side on separate barges left New Orleans en route up the Mississippi River to MSFC. On one of the dual barges rode the Saturn V test stage, S-IC-T, after its successful 15-second firing on this March 3 date. The other barge brought the tenth Uprated Saturn booster, S-IB-10, from Michoud to MSFC for static tests. And at KSC the stages of the sixth Uprated Saturn, SA-206, were leaving Launch Complex 37 for return to various sites for storage. The S-IB-9 stage was leaving MSFC by barge. The second stage for SA-206 (S-IVB-206) would make better trip time, leaving two weeks later aboard the Super Guppy aircraft from KSC to Huntington Beach for storage at Douglas Aircraft Company plant. Also in March the instrument unit for SA-206 left by aircraft for the IBM plant in Huntsville for storage. These various movements came because SA-206 was to have launched an unmanned lunar module on its first space test, but subsequent scheduling redesignated SA-204 for that mission.

331



331. S-IC-2 stage being moved from ME lab

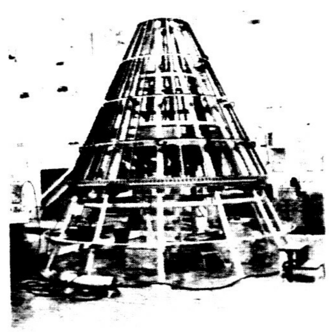
332



332. J-2 at AEDC, Tullahoma, Tennessee

333. Alignment tool for stringer installation, SA-203 nosecone

333



SA-206 would remain in storage for use in a subsequent mission.

On March 7, NASA signed an incentive contract with the Boeing Company for Saturn V Systems Engineering and Integration (SE&I) requirements as Schedule II, NAS8-5608, for target costs and target fees of $720.4 million. This requirement extended the SE&I effort through December 1968.

On March 14 MSFC completed at Huntsville a series of acceptance test firings of S-IB-9. During this same week the S-IC-2 stage arrived by barge at KSC. Also during this week scientists at Arnold Engineering Development Center, Tullahoma. Tennessee, started and restarted a J-2 rocket engine in simulated altitude tests, a significant accomplishment in improving the engine's readiness for restart missions in space. Such tests duplicated the extreme temperatures and other environmental factors of 100,000 feet above earth. Earlier tests at Tullahoma had confirmed the J-2 engine performance for the Uprated Saturn vehicle.[349]

Factory checkout of S-IVB-210 ended on March 22. Joining of the thrust structure and aft structure of S-IVB-211 began on March 27. At SACTO on the same day workmen installed the S-IVB-209 stage in the vertical checkout laboratory.[350]

After the shipment from MSFC on March 3 of the last S-IC-2 stage, the MSFC ME Lab shifted its workload emphasis from the S-IC program to a variety of smaller Saturn/Apollo vehicle and payload projects. Preliminary planning began on a Multiple Docking Adapter and planning continued on the Apollo Telescope Mount.[351]

Late in this first quarter of calendar year 1967 the first Uprated Saturn nosecone (for AS-203) went from MSFC to KSC. Nosecones No. 2 and No. 3 progressed through assembly at ME Laboratory at MSFC.[352]

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334. *S-II firing at MTF*

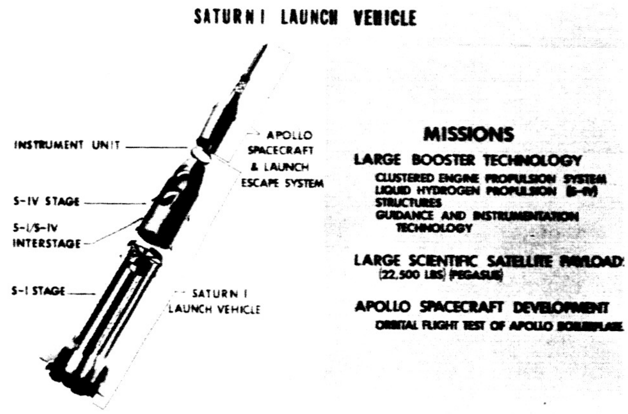
Saturn ended its tenth year in April of 1967 with a number of successful and significant tests. During this month engineers completed ten weeks of dynamic testing of the Apollo/Saturn V space vehicle at the Marshall Center, tests that included more than 150 hours of "shaking" the vehicle. MSFC officials described the tests, conducted by Boeing, as "very much a success." At MTF the second flight version of the Apollo/Saturn V second stage, S-II-2, underwent a successful full-duration captive firing. During this April 6 test a cluster of five J-2 engines fired for a full duration of 6 minutes, 6 seconds.[353] North American Aviation, prime contractor for S-II, conducted the test at MTF's A-2 test stand. On April 10 the S-IC-T and S-IB-10 arrived at MSFC after traveling on barges side by side from New Orleans.

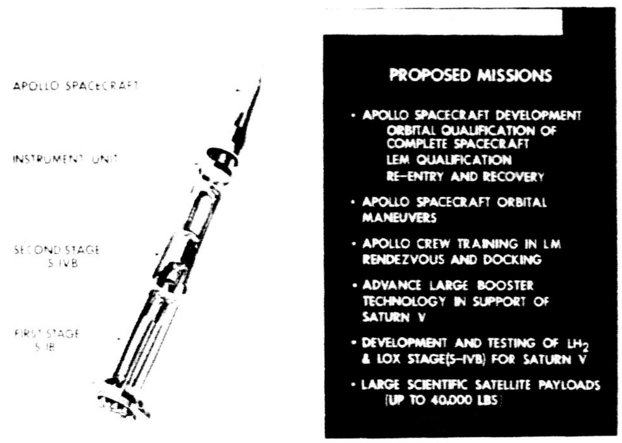
On April 15, 1965, the S-II-2 was captive fired for the second time at MTF. This was a full-duration firing.

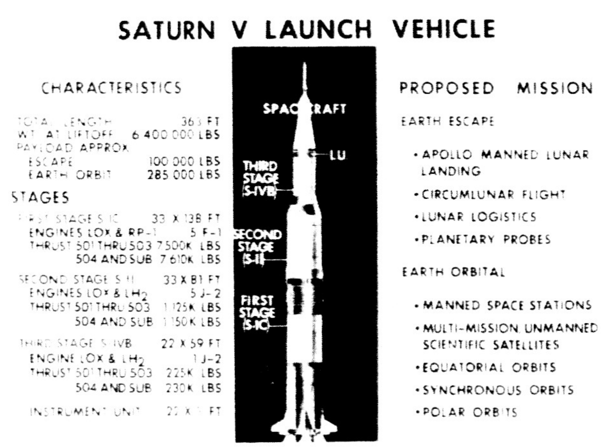
ACKNOWLEDGMENT

Various personnel have contributed generously to the preparation of this chronology. In the past ten years first one organization and then another has had a variety of responsibility for its preparation. Therefore, seekers of more detailed information may well appreciate the names of people who have contributed to various versions. At MSFC Mr. Robert Sampson of Research and Development Operations and Mr. Harold Price of Industrial Operations were pioneers in preparing the chronology's early versions. Later Mrs. Evelyn Falkowski, Mrs. Rowene Dunlap, Miss Ruth Jarrell, and Mr. Leo L. Jones, all of Management Services Office Historical Office, have helped much in either writing, editing, or researching for the document. Mrs. Dunlap in particular has been closely associated with it in her capacity as Editorial Clerk. For other assistance including layout we are also indebted to personnel of RCA, support contractor for Management Services Office. These people most closely identified with the project are Miss Teresita Sellers, Mrs. Kay Parrish, Mrs. Pat Vidler, Mr. Dan Wise, and Mr. Fagan Thompson.

APPENDIX A. SATURN MISSIONS

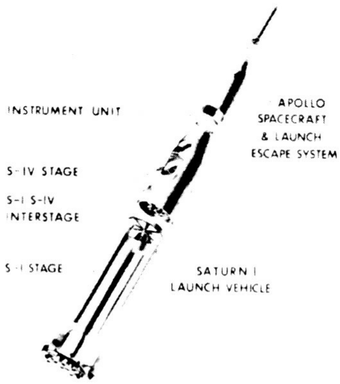






APPENDIX B. SATURN CHARACTERISTICS

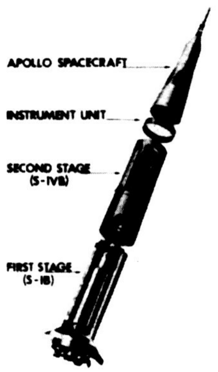
SATURN I LAUNCH VEHICLE



CHARACTERISTICS

LAUNCH VEHICLE	
LENGTH	124 FT
WEIGHT AT LIFTOFF	1,138,000 LBS
PAYLOAD CAPACITY	22,500 LBS
STAGES	
S-I	
SIZE	21.5 X 80 FT
THRUST	1,500,000 LBS
ENGINES	8 H-1
PROPELLANT	LOX & RP-1
S-IV	
SIZE	18.3 X 41 FT
THRUST	90,000 LBS
ENGINES	6 RL10
PROPELLANT	LOX & LH_2
INSTRUMENT UNIT	
SIZE	12.8 X 3 FT
GUIDANCE SYSTEM	INERTIAL
TOTAL LENGTH (INCLUDING SPACECRAFT & LES)	190 FT

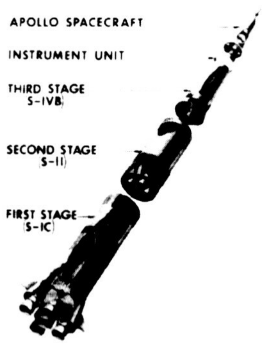
SATURN IB LAUNCH VEHICLE



CHARACTERISTICS

LENGTH (VEHICLE)	142 FT
LENGTH (VEHICLE, SPACECRAFT, LES)	224 FT
WEIGHT AT LIFTOFF	1,297,000 LBS
EARTH ORBIT PAYLOAD	40,000 LBS
STAGES	
FIRST (S-IB)	
SIZE	21.5 X 80 FT
ENGINES	8 H-1
THRUST (201 THRU 205)	1,600,000 LBS
(206 AND SUB)	1,640,000 LBS
PROPELLANT	LOX & RP-1
SECOND (S-IVB)	
SIZE	22 X 59 FT
ENGINE	1 J-2
THRUST (201 THRU 207)	200,000/225,000 LBS
(208 AND SUB)	205,000/230,000 LBS
PROPELLANT	LOX & LH_2
INSTRUMENT UNIT	
SIZE	22 X 3 FT
GUIDANCE SYSTEM	INERTIAL

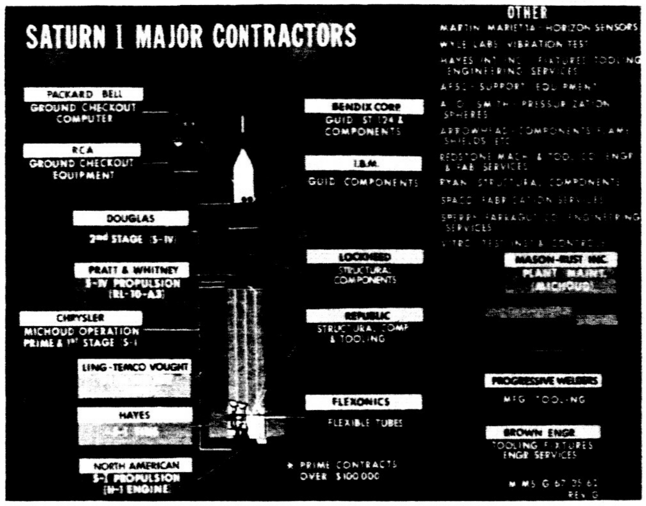
SATURN V LAUNCH VEHICLE

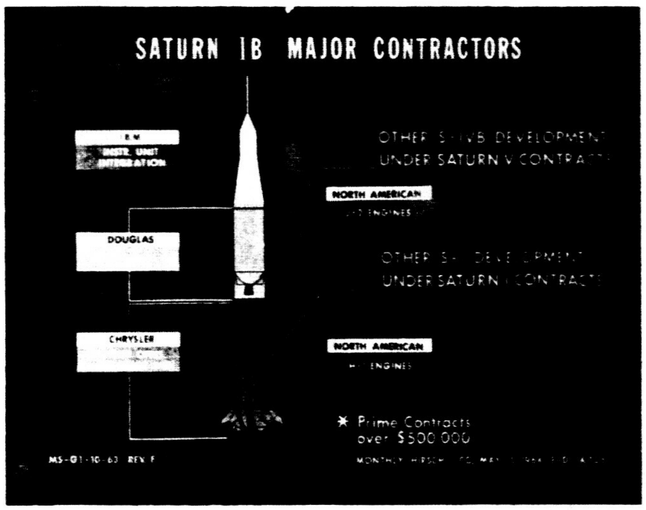


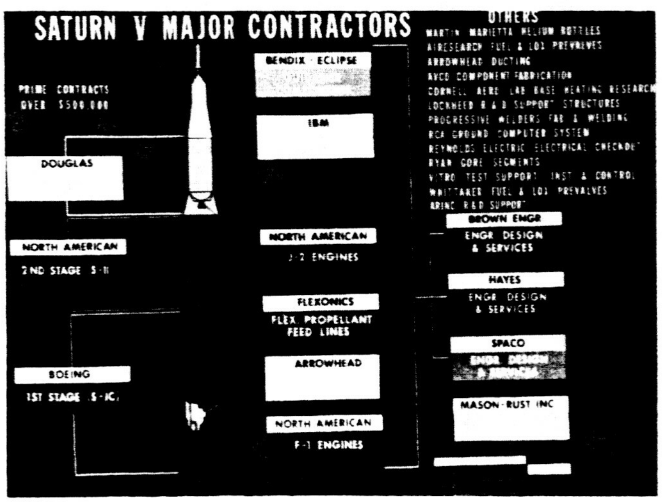
CHARACTERISTICS

LENGTH (VEHICLE)	281 FT
LENGTH (VEHICLE, SPACECRAFT, LES)	363 FT
WEIGHT AT LIFTOFF	6,400,000 LBS
PAYLOAD CAPABILITY APPROXIMATE	
TRANSLUNAR TRAJECTORY	100,000 LBS
EARTH ORBIT	285,000 LBS
STAGES	
FIRST (S-IC)	
SIZE	33 X 138 FT
ENGINES	5 F-1
THRUST (501 THRU 503)	7,500,000 LBS
(504 AND SUB)	7,610,000 LBS
PROPELLANTS	LOX & RP-1
SECOND (S-II)	
SIZE	33 X 81 FT
ENGINES	5 J-2
THRUST (501 THRU 503)	1,125,000 LBS
(504 AND SUB)	1,150,000 LBS
PROPELLANTS	LOX & LH_2
THIRD (S-IVB)	
SIZE	22 X 59 FT
ENGINE	1 J-2
THRUST (501 THRU 503)	225,000 LBS
(504 AND SUB)	230,000 LBS
PROPELLANTS	LOX & LH_2
INSTRUMENT UNIT	
SIZE	22 X 3 FT
GUIDANCE SYSTEM	INERTIAL

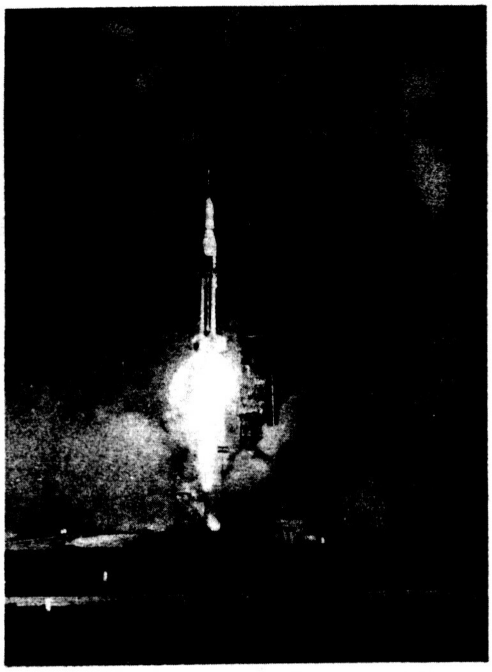
APPENDIX C. SATURN MAJOR CONTRACTORS







SATURN I LAUNCH SUMMARY



RESEARCH AND DEVELOPMENT FLIGHTS

SA-1
1. LAUNCHED-OCT. 27, 1961
2. S-I STAGE PROPULSION SYSTEM SATISFACTORY

SA-2
1. LAUNCHED-APR. 25, 1962
2. PROJECT HIGHWATER RELEASED 22,900 GAL H_2O INTO IONOSPHERE

SA-3
1. LAUNCHED-NOV. 16, 1962
2. 2ND PHASE PROJ HIGHWATER
3. FULL PROPELLANT LOADING

SA-4
1. LAUNCHED-MAR. 28, 1963
2. ENGINE OUT CAPABILITY DEMONSTRATED

SA-5
1. FIRST BLOCK II LAUNCHED-JAN. 29, 1964
2. FIRST LIVE S-IV STAGE AND INSTRUMENT UNIT

SA-6
1. LAUNCHED-MAY 28, 1964
2. FIRST ACTIVE GUIDANCE FLIGHT
3. FIRST FLIGHT APOLLO BOILERPLATE AND LES
4. ENGINE OUT (UNPLANNED)

OPERATIONAL FLIGHTS

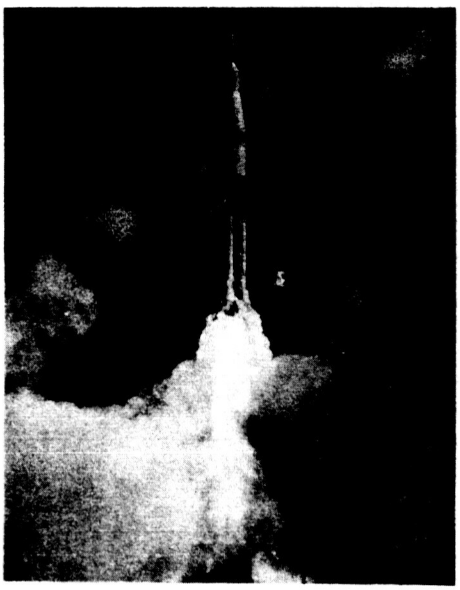
SA-7
1. LAUNCHED-SEPT. 18, 1964
2. COMPLETELY ACTIVE-ST-124 GUIDANCE

SA-9
1. LAUNCHED-FEB. 16, 1965
2. FIRST PEGASUS (METEOROID TECHNOLOGY SATELLITE) ORBITED
3. FIRST UNPRESSURIZED INSTRUMENT UNIT

SA-8
1. LAUNCHED-MAY 25, 1965
2. ORBITED SECOND PEGASUS SATELLITE

SA-10
1. LAUNCHED-JULY 30, 1965
2. ORBITED THIRD PEGASUS SATELLITE
3. COMPLETED SATURN I PROGRAM

SATURN IB LAUNCH SUMMARY

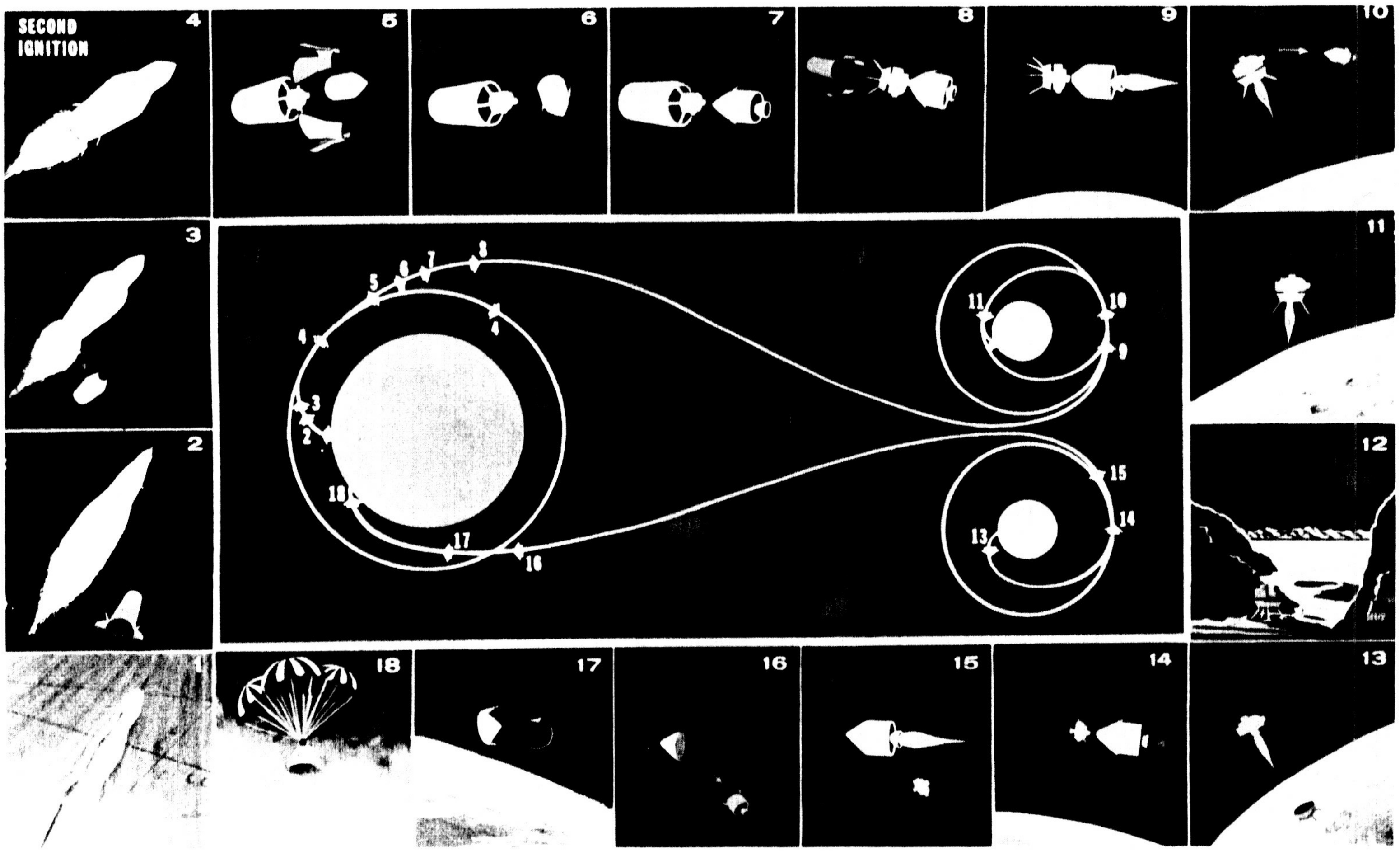


AS-201
1. LAUNCHED FEB 26, 1966
2. SHORT LOB-LAUNCH VEHICLE AND CSM DEVELOPMENT

AS-203
1. LAUNCHED JULY 5, 1966
2. ORBITAL LIQUID HYDROGEN EXPERIMENT

AS-202
1. LAUNCHED AUG 25, 1966
2. LONG LOB-LAUNCH VEHICLE AND CSM DEVELOPMENT

AS-204 APOLLO 5
1. LAUNCHED JAN 22, 1968
2. ORBITAL LUNAR MODULE DEVELOPMENT



APPENDIX E: SEQUENCY FOR SATURN V MANNED LUNAR VOYAGE

GLOSSARY

A

ABMA	Army Ballistic Missile Agency
AEC	Atomic Energy Commission
AEROJET	Aerojet General Corporation
AF	Air Force
All-Systems Vehicle	Non-flight stage used to checkout flight-worthiness of systems
AIAA	American Institute of Astronautics and Aeronautics
AMR	Atlantic Missile Range
AOMC	Army Ordnance Missile Command
Apollo	Project designation for manned lunar landing, also spacecraft for manned lunar landing
AS	Apollo/Saturn (Specific payload and vehicle with a number as AS-203)

B

Battleship Stage	Non-flight stage replica for engine tests
BP	Boilerplate
"Bug"	Lunar excursion module, landing unit of the Apollo Spacecraft

C

C-1	Saturn C-1, early nomenclature for Saturn I

C-3	Saturn C-3, Saturn configuration considered but not used
C-5	Saturn C-5, configuration adopted for lunar landing Apollo flights (renamed Saturn V in February 1963)
C-IB	Saturn C-IB, vehicle selected in 1962 for manned earth orbital flights with full Apollo spacecraft (renamed Saturn IB)
Cape Canaveral	Launch site, name changed to Kennedy Space Center in 1963.
CCSD	Chrysler Corporation Space Division
CBTT	Common bulkhead test tank
Chance-Vought	Saturn tank manufacturer, Dallas, Texas
Centaur	Vehicle for support of unmanned moon probes and other missions
Compromise	Later changed to Promise - barge transporter for Saturn boosters
CPFF	Cost-plus-fixed-fee contract
CPIF	Cost-plus-incentive-fee contract

D

DAC	Douglas Aircraft Corporation
DOD	Department of Defense
Downey	S&ID S-II stage component fabrication and testing facility location
Douglas	Douglas Aircraft Corporation

Dyna Soar	Air Force spacecraft for earth orbital flight featuring "glider re-entry"
DX rating	Highest national priority
	E
ESE	Electrical Support Equipment
	F
FAA	Federal Aviation Agency
Fairchild Stratos	Meteoroid satellite contractor
F-1 Engine	Saturn V booster (S-IC stage) engine
FRT	Flight Rating Tests
	G
GSE	Ground Support Equipment
	H
H-1 Engine	Saturn I booster (S-I stage) engine
High Water Project	SA-2 and SA-3 flight experiment in which water from the Dummy second stage was released into the ionosphere.
Huntington Beach	DAC S-IVB assembly facility in California
	I
IBM	International Business Machine Corporation
IO	MSFC Industrial Operation organization

IU	Instrument Unit
	J
J-2	Liquid hydrogen engine for S-IVB and S-II stages
JPL	Jet Propulsion Laboratory
	K
K	Thousands of pounds of thrust
KSC	Kennedy Space Center, was Cape Canaveral until November 28, 1963.
Kiwi-B	Nuclear reactor
LC	Launch Complex
LOC	Launch Operations Center
LOX	Liquid Oxygen
Lockheed	Lockheed Aircraft Company
LH_2	Liquid hydrogen
LR-115	First Liquid hydrogen type engine (Pratt & Whitney) , early designation of RL 10-A3 engine.
LR-119	Proposed uprated LR-115 engine (project was cancelled)
	M
Martin	Martin Company
ME	MSFC's Manufacturing Engineering Laboratory

Michoud	NASA's Michoud operations
Minneapolis-Honeywell	Minneapolis-Honeywell Incorporated name changed to Honeywell Incorporated
MSC	Manned Spacecraft Center
MSFC	George C. Marshall Space Flight Center
MSTS	Military Sea Transport Service
MTF	Mississippi Test Facility (at one time MTO) in Hancock County, Mississippi
	N
NASA	National Aeronautics and Space Administration
NERVA	Nuclear engine for RIFT stage
NOVA	Moon direct flight vehicle deferred in favor of Saturn V
	P
P&VE	Propulsion and Vehicle Engineering Laboratory at MSFC
Pegasus	Meteoroid detection satellite
PFRT	Preliminary Flight Rating Test
P&W	Pratt & Whitney Company
	R
R&D	Research and Development
RCA	Radio Corporation of America
Rocketdyne	Division of North American Aviation

RIFT	Reactor-in-flight test stage (nuclear power)
RP-1	A kerosene-type fuel
RL10-A3	Reactor-in-flight test stage (nuclear power)

S

SA	Saturn (with number signifies a specific vehicle as SA-501) that does not have the Apollo command module attached.
S-I	Saturn I originally Saturn C-1 first stage
S-II	Saturn V second stage
S-IVB	Saturn V third stage
S-IC	Saturn V first stage
S-IV	Saturn I second stage
SACTO	Douglas Aircraft's Sacramento Test Facility
Santa Susana	Test site for S-II and S-IVB stage and J-2 engine
Santa Monica	Douglas Aircraft's fabrication facility at Santa Monica, California
Saturn I	A two-stage vehicle, with eight H-1 engines propelling first stage and six RL-10 engines propelling second stage
Saturn IB	A two-stage vehicle with eight H-1 engines propelling first stage and a single J-2 engine propelling second stage

Saturn V	A three stage vehicle, with five F-1 engines propelling first stage, five J-2 engines propelling second stage, and a single J-2 engine propelling third stage
Seal Beach	North American Aviation Assembly plant at Seal Beach, California
S&ID	Space and Information Systems Division of North American Aviation
Slidell	A computer center that serves Michoud in Slidell, La.
SSO	Saturn Systems Office
Sverdrup Parcell Company	Mississippi Test Facility design contractor
	U
Uprated Saturn	Nomenclature used for S-IB for a short period of time.
	V
VAB	Vertical Assembly Building

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